Swedish Civil Contingencies Agency

Physical limit values

Summary and discussion of Report 3 on the project "The Physical Capacity of Firemen"

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Swedish Civil Contingencies Agency (MSB)

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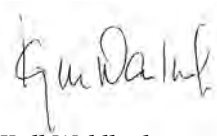
Foreword

Traditionally, emergency services attach great importance to physical strength when judging who is suitable for the profession of fireman. For that reason, considerable attention has also been focused on how physical capacity should be measured. The report from the Winternet Research and Education Centre, on which this summarizing document is largely based, is the third in a series of studies funded by the MSB and the former Swedish Rescue Services Agency (SRSA). It is pleasing that we have taken a further step forward in developing test procedures to measure the strength appropriate to the most strenuous job operations. The model represents a useful aid to individual physical training. At the same time, we can be clear that according to the latest study the requirement for physical strength has been set high. Many of those tested, today working as firemen, did not achieve the "pass" level in the study. This provides us with further arguments for taking the next step forward. We cannot just accept that a number of tasks today are onerous. We must drive research forward in order to develop new tools and methods, and the modern technology that is already available must be used by the rescue services. It is something that everyone gains from. One result will be a more efficient rescue service, another will be a reduction in the risk of firemen sustaining occupational injuries.

The rescue service of the future will demand new, up-to-date organizational and work structures that play a part in developing working roles. The rescue service has to break down the one-dimensional focus on physical strength in every individual when recruiting firemen. The requirements set must strike a better balance between physical capacity and other qualities that are equally important in the profession. Rescue service units should be viewed as a team in which different individuals contribute different abilities.

The Swedish Association of Local Authorities and Regions and the Swedish Civil Contingencies Agency would like to see an all-inclusive approach to recruitment.In that way, we can help to shape a rescue service that is equipped for the future.



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Content

Three studies of strength among firemen

One major challenge when recruiting new firemen is to identify tests that best correspond to the physical demands placed in the separate and combined work efforts required of firemen. Each individual employer decides on which physical tests and levels of requirement are to be used. Depending on the risk scenario and population base in the particular municipality, the tasks of the firemen will vary from one location to another. Against that background, first the Swedish Rescue Services Agency and then the MSB initiated a number of studies over the past decade to further analyze this issue.

Typical tasks

The project report "The Physical Capacity of Firemen: Report 1 – Typical Tasks" was published in 2001 by the Swedish Rescue Services Agency (SRSA). The study was conducted by researchers at the Swedish National Institute for Working Life. The intention was to develop a number of typical tasks including limit-setting job operations. Via a questionnaire, firemen were asked to assess the occurrence of various job operations and how strenuous they were. In addition, statistics on work efforts were analyzed. From this process, nine typical tasks emerged on the basis of the most common and most demanding operations. These included four types of breathing apparatus rescue and lifesaving in different environments. Other operations included firegas ventilation via roof venting, extinguishing of forest fire, cross-country stretcher bearing, surface lifesaving in an accident-at-sea situation and freeing a person from a car in a road accident situation. The physical requirements used as criteria in selection were muscular strength in the hand, arm, trunk and leg; oxygen uptake capacity; physical control (coordination); working position combined with demanding muscular work and endurance.

The typical tasks were developed for the purpose of serving in a future study as the basis for developing standard tasks for firemen. These were intended to indicate suitable tests for physical capacity in the recruitment of new firemen.

Physiological tests

The follow-up project emanated a few years later in the report "The Physical Capacity of Firemen: Report 2 – Physiological Tests" (2005). This, too, was issued by the SRSA, but in this case by researchers at

the Winternet Research and Education Centre at Luleå University of Technology. On this occasion, the objective was to develop a number of simply performed physical tests directly related to the performance of the job operations described in Report 1. Characteristics such as psychological factors, technical competence and logical capability were not assessed.

The study pointed out that a relevant variable during measurement of work effort is the intensity at which the task is performed. This means that even if certain work efforts require a high level of oxygen consumption, it is perhaps not just this factor that is the limit-setting one. In complex tasks, there are opportunities for various forms of compensation, which offers a certain "resistance to fatigue". The time factor affects different types of tasks to a greater or lesser extent. In life-saving situations, time is critical to the task, which often involves maximum physical effort over a fairly brief period. Type of equipment also makes a difference, for example whether the air cylinders are made of steel or composite material. Finally, the method of working also plays an important part in determining how physically demanding a certain task is perceived to be.

Most demanding job operations

Studies performed indicate that seven out of the various job operations of firemen are subjectively crystallized into the most demanding and most commonly occurring. These are: roof venting, freeing a person from a car, carrying a firehose basket across country, stair climb with firehose basket, hose drag, ceiling breach and dummy drag.

Breathing apparatus rescue is not included despite the fact it is regarded as being among the most physically demanding work efforts. One explanation for this is that measuring the impact of heat on individuals is complicated. Another factor is that the Swedish Work Environment Authority has already issued special instructions for breathing apparatus rescue in smoke and chemical fume environments.

It is thought that five of the most demanding job operations can be measured with the aid of eight separate tests, which are described later in this document. Treadmill and exercise bicycle tests proved to underestimate the oxygen uptake capacity of women and overestimate that of men . On that basis, they were not recommended as forms of testing, and only for medical assessment.

Limit values

The latest report on the physical capacity of firemen "Report 3 – Physical limit values", published in autumn 2011, largely comprises the findings of the study reported in the present document. The objective here was to determine limit values for the physical capacity for work that may be applied in the recruitment of new firemen. The report is based on three sub-studies with the same number of objectives. Firstly, to repeat the questionnaire from Report 1 on typical tasks, and to compare the results published in 2001 and 2011. Secondly, to describe the results of external tests performed at rescue services and in the Precautions Against Accidents (Skydd Mot Olyckor, SMO) training organization. The third objective, and the objective of the study, was to propose physical limit values that may serve as guidelines in the recruitment of new firemen.

Besides full- and part-time firemen of both genders, the project also included a group of non-firemen. The study was carried out at Winternet, a research and education centre focusing on sport, fitness, health, public health and rehabilitation, based in Boden. Physical tests were performed at rescue services in Luleå, Lund and Södertörn.

Physical tasks in the fireman's job

On operational duty a fireman needs a number of characteristics to do the job. Physical strength is one of them. Heavy work must be done quickly and safely. Studies have shown that in certain situations firemen subjectively perceive that they are exerting a lot of effort. One reason for using limit values for physical capability is to ensure that the individual has sufficient strength for the task and thus avoid or reduce work-related injuries. On the other hand there is a risk of excluding individuals who from a holistic perspective do have sufficient physical capability – not least considering their other personal qualities and the overall balance of competence in the work team. A number of heavy tasks in the working day of a fireman have been considered in formulating the physical tests. These tasks are:

- Carrying hose baskets upstairs
- Dragging hoses
- Dismantling an inner ceiling
- Dummy drag (task simulation)
- Carrying hoses over ground

Body weight and height are individual factors that affect how work is carried out. Some tasks are so unusual that they were not considered when formulating the tests in the three sub-studies. One example of this is entering a smoke-filled environment onboard a ship.

Forms of testing for physical strength

In Sweden, statistics are available on operational time (from alarm to start of action). On the other hand, there is no data on completion time for rescue operations (from start to finish on site). Because the performance of the work is also affected by location, time, terrain, weather conditions etc., it is nevertheless impossible in practice to establish by measurement how long an operation should take. One objective in the project in hand was to arrive at "reasonable limits" for what a fireman should be capable of under certain time constraints.

Based on the typical tasks established by research earlier, the following tests have been studied and given limit values:

- Maximum grip strength
- Rowing 500 metres
- Bench press with 30 kilos
- Standing long jump
- Running 3,000 metres
- Lift to chin, 7.5 kilos and 15 kilos

Physical performance depends partly on the complexity of the task. This means that a lower test value for one operation can be compensated by a higher one in another. The more complex the task, the more important the all-body performance is. It should be noted that a person with physical test results below the recommended limit values may very well execute his/her task, but that in all likelihood it will take longer. Furthermore, it cannot be guaranteed that a person with acceptable test results will deliver a satisfactory job performance. Finally, the profession of fireman includes a whole range of tasks from fairly light to extremely onerous job operations. As a result, the aim of this study was to establish limit values to serve as reasonable limits for general physical capacity on the part of firemen. An all-inclusive perspective on the specific tests may help create the capacity to predict how quickly and how well a certain individual will manage to carry out a particular task.

How demanding are the tasks?

Subjective perception of the fireman

Each fireman's own perception of how physically demanding a task can be is a key starting point in developing suitable tests and limit values. Firemen in 28 Swedish municipalities and emergency services associations answered questions about specific tasks in their job both over the past three years and also throughout their career (32 municipalities participated in sub-study 1). The firemen were also asked to assess the perceived load with regard to physical fitness, hand, arm, leg and trunk strength, working position and physical control.

The relevance of the results from 2001 was further reinforced via a questionnaire repeated ten years later.

The two surveys revealed that the same three tasks that were most common in 2001 were still the most common in 2011. These tasks were connecting hoses and pipes, moving equipment from the truck to the incident scene and starting up machines. There was no difference between the surveys in the perception of strength required to perform these tasks. The same tasks were therefore surveyed in both sub-study 3 and sub-study 2.

Physical fitness

Three tasks emerge as the most physically demanding when firemen assess their own efforts. These are carrying a person out of a smoke-filled or chemical-filled building, hose drag across country, and life-saving and carrying of an injured person across 30 metres of terrain. Several other tasks scored highly in terms of physical effort but had only been performed by a minority of firemen.

Hand strength

The three most demanding tasks in terms of hand strength, as perceived by the firemen themselves, were cross-country stretcher bearing, tightening a hose, and life-saving in smoke-filled or chemical-filled buildings. Starting a machine was perceived as being the lightest task in terms of hand strength.

Arm strength

The following four tasks were perceived as most demanding in terms of arm strength: cross-country stretcher bearing, life-saving in smoke-filled or chemical-filled buildings, tightening a hose filled with water, and hose drag across country. Starting a machine and connecting or disconnecting a hydrant head were perceived as being the lightest tasks in terms of arm strength.

Leg strength

Firemen need strong legs to do their work. The most demanding tasks for their legs were perceived as being cross-country stretcher bearing, life-saving in smoke-filled or chemical-filled buildings, and hose drag across country. The least demanding tasks for the legs were using a wide hose to extinguish a fire from the outside and fire gas ventilation via roof venting. One task that few had performed, but which was perceived as requiring limited leg strength by those who had performed it, was evacuating animals from a building.

Trunk strength

Cross-country stretcher bearing, life-saving in smoke-filled or chemical-filled buildings, hose drag across country and moving an injured person out of a critical area – these tasks were perceived as requiring the greatest trunk strength. Securing objects in a storm and evacuating animals from a building were perceived as being fairly or very demanding – for trunk muscles especially – by the relatively few respondents who had carried them out.

Working position

The most demanding tasks in terms of working position were considered to be life-saving in a smoke-filled building and carrying hoses up four storeys whilst wearing breathing gear. Removing or securing material in a storm and hoisting material with a rope were considered to be least demanding in terms of working position.

Physical control (coordination)

Some tasks require greater balance and coordination than others. They include life-saving outdoors on a ladder and walking across a roof. Removing storm-damaged trees and preventive dismantling during and after a fire were considered less demanding for physical coordination.


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Analysis of limit values

Tests were carried out on 87 individuals in three categories over a period of six months (September 2010 – March 2011): full- and part-time firemen and a control group of non-firemen. Each category was divided into men and women, giving rise to a total of six analysis groups. In addition to data from these test subjects, the findings from tests carried out ten years earlier (Report 1) were added, making 128 test subjects in all. The groups were divided into full-time firemen (21 men and 17 women), part-time firemen (21 men and 23 women) and non-firemen (22 men and 24 women). A certain level of statistical wastage was noted and in practice not all individuals performed all tests. There are also certain differences in the way the tests were carried out, affecting the results reported in 2001 and 2011, respectively.

Participants

The test subjects participated voluntarily and on an unpaid basis, which may have affected the representivity of the selection. Participating firemen were recruited through contact with the fire and rescue services. Other individuals were recruited via Brandmännens Riksförbund (BRF) [the Swedish National Union of Firefighters], Räddningstjänstens idrotts- och testledare (RIT) [the Swedish Association of Sports and Test Supervisors in the Rescue Services], Heltidsanställda kvinnliga Brandmän (HkBm) [the Swedish Association of Full-Time Employed Firewomen], Utbildningen i Skydd mot Olyckor (SMO) [the Precautions Against Accidents training organization] and regional promoters of diversity. Non-firemen participated as a control group. These individuals were recruited for example via advertisements posted in gyms and via the contacts of other participants. It was considered that including in the study not only people who train regularly, but also those who train less frequently would make identification of upper and lower limit values easier. It was concluded that all the groups participating in the study train more often than Swedes in general, even if some of these test subjects did not train on an especially regular basis.

The basic information collected before the tests consisted of age, blood pressure, Body Mass Index (BMI) and number of training sessions per week. Differences between the groups occurred, in terms of the number of training sessions per week. Full-time firemen, women, train more frequently than part-time firemen, men and non-firemen of both genders. Part-time firemen, women, trained more than non-firemen, men.

External tests

Test supervisors at rescue services and at SMO [the Precautions Against Accidents training organization] performed physical tests in order to screen the physical strength of Swedish firemen. In all, 329 test subjects participated in these tests, divided into the following categories: firemen (151 men and 6 women), new recruitment tests (48 men and 19 women) and SMO trainees (77 men and 28 women). The data collected referred to body height and body weight. The data also comprised the results of physical tests carried out for maximum grip strength, rowing 500 metres, bench press with 30 kilos, standing long jump, running 3,000 metres and 7.5 kilo lift to chin. In some cases, the 15 kilo lift to chin test was also included. The results of these external tests did not affect the determination of the physical limit values. For more information, see *"The Physical Capacity of Firemen – Report 3" (2011)".*

How the tests were conducted

On the first test day, the test subjects were asked to complete a health check form. Blood pressure was checked after ten minutes rest, and the individual's height and weight were recorded. Tests relating to four job operations were then carried out, namely, stair climb with firehose basket, hose drag, ceiling breach and dummy drag. These were carried out successively with two minutes of active rest between each work location. The break for rest was intended to represent the time taken to change location from one job operation to another.

Day Two comprised six different test operations. During the morning, maximum grip strength, rowing 500 metres and bench press with 30 kilos were tested. In the afternoon, the 7.5 kilo lift to chin using Z-bar, standing long jump and running 3,000 metres tests took place.

On the third day of testing, the 15 kilo lift to chin using Z-bar test, then carry firehose basket across country were carried out.

Most test subjects (82 percent) performed tests for three days in a row. However, the longest gap elapsing between the two test occasions for individuals was 180 days. The days of testing were not arranged in numerical order for all test subjects, meaning that some could perform test day 2 before test day 1 and so on. On the other hand, all test operations were carried out on the respective test day in accordance with the sequence ordered.

Test equipment

For detailed information on test equipment, please see Report 3 (2011). In the case of the tests for simulated job operations, the stair climb with firehose basket test used large 16 kilo firehose baskets intended for double narrow-gauge hose. The hose drag test was performed using 25-metre 63 millimetre wide-gauge hose filled with water. The drag resistance was measured in a test of dragging 22-26 kilos across a smooth cement floor. In the first 38 hose drag tests, a 63-millimetre heavy rope was used instead, with a drag resistance of 22 kilos. The ceiling breach test was carried out using a Z-bar and 7.5-kilo weights. A 75-kilo training dummy was used in the dummy drag test. In the carry firehose basket across country test, 18.7 kilo firehose baskets for double wide-gauge hose were used.

Test environments and equipment show several (but very minor) differences between test occasions and test locations.

Tests compared with actual job operations

One pertinent question that needs to be asked is how close the physical tests are to the job operations in reality. The research project studied statistical correlations between tests and simulated job operations.

Analyses of correlations indicated that certain tests were closer to the reality of job operations than others. In the lift to chin tests, it emerged that the 15-kilo load more closely resembled the job operations studied than the 7.5-kilo one, and as a result the 7.5-kilo lift was subsequently omitted from the analysis. The 3,000-metre running test showed a close correlation with all job operations except carry firehose basket across country, if the results were reported as time per kilo of body weight (seconds/kilo) rather than simply expressed in time (seconds).

TEST	GRIP	ROWING	BENCH	JUMP	RUNNING	LIFT TO CHIN
Stair climb with firehose basket	X	X		X	X	
Horse drag	X		X	X	X	
Ceiling breach		X	X	X	X	X
Drag dummy	X	X	X	X	X	
Firehose basket across country	X	X		X	X	

Tests relevant to different job operations.
Source: "The Physical Capacity of Firemen: Report 3 – Physical limit values (2011)", page 79.

Tests marked X indicate that these are either relevant to a whole category (full- or part-time firemen, or non-firemen), alternatively for women or for men.

Tests of simulated job operations

The tests that proved to best explain the most onerous and most commonly occurring job operations of firemen were conducted within the project. The exercises are described below. Finally, a summary is presented of the performance data for the different test subject categories.

Stair climb with firehose basket

The test was carried out in a training tower with the test subject wearing firefighting jacket, breathing apparatus, gloves, own trousers and trainers. The conditions differed slightly from one location to another.

The test was arranged in three stages. Initially, preparation consisted of the test supervisor placing two firehose baskets, wound with double narrow-gauge hose, on the floor by the first step of the flight. Then – at the signal to start – the test subject carried both firehose baskets (one in each hand) up to the designated floor at the same time. The timer was stopped when the firehose baskets were placed on the landing at the top step. The firehose baskets were moved a vertical distance of 13.2-13.6 metres. After this, the test subject returned to the starting point to repeat the same exercise after 60 seconds. The instruction was to carry the firehose baskets up as quickly as possible and to place at least one foot on each step. The time taken to perform the work was recorded in seconds.

Hose drag

This test began 2 minutes after completion of the stair climb with firehose test and was conducted indoors or in a cooled store room. In the test, the test subject was dressed in the same way as in the previous exercise. The test was carried out under slightly different conditions for different test subjects. Some had a 70-millimetre heavy rope. Others dragged a water-filled 63-millimetre wide-gauge hose over smooth concrete.

The test began after preparation in which the test supervisor laid out 25 metres of heavy rope or hosepipe (marked at 20 metres) on the floor. Before starting, the test subject gripped the hose or rope. At the starting signal, the rope was pulled in at maximum speed. The timer was stopped when the test subject had moved the hose or rope 20 metres.

The instruction was to pull in the hose/rope as quickly as possible, while standing on the same spot. The time taken for the exercise was recorded in seconds.

Ceiling breach

This test started 2 minutes after completion of the hose drag and was conducted indoors or in a cooled store room, with the test subject wearing firefighting jacket, breathing apparatus, own trousers and trainers.

Preparation for the exercise consisted of securing a line between floor and ceiling. Heights of 140 and 190 centimetres from the floor were marked on the line. A Z-bar (weighing 8.5 kilos) was secured to the ceiling so the fastening between cord and rod was 190 centimetres above the floor at the left end of the bar. At the other end of the Z-bar (the right end), three 2.5 kilo weights (or the equivalent) were installed. At both ends, a bracket was fitted with the 0.25 kilo weight. Thus, the moment arm from suspension to the centre of the weights was 101 centimetres.

Before starting, the test subject placed one hand immediately to the right of the weights and one immediately to the left of the weights. The individual stood in such a way that the dominant arm would perform the heaviest work. The end of the rod was then lifted between the mark at 140 centimetres and the mark at 190 centimetres at a rate of 25 completed lifts per minute. The instruction was to carry out as many lifts as the test subject could manage. The number of lifts was recorded. Only lifts performed at the designated rate were recorded.

Drag dummy

The test began 2 minutes after completion of the ceiling breach test and was carried out indoors on a level surface (cement or asphalt), with the test subject wearing firefighting jacket, breathing apparatus, gloves, own trousers and trainers.

Preparation consisted of placing a rescue dummy weighing 75 kilos, fitted with a harness around chest and shoulders, behind the starting line and making a mark on the floor 30 metres from the starting line. Before the starting signal, the test subject gripped the harness. The dummy was then dragged backwards to 30 metres at maximum speed. The instruction was to move the dummy 30 metres as quickly as possible, walking or running backwards. The time was taken when the head of the dummy reached the finish line.

Carry firehose basket across country

This exercise started 60 minutes after the 15 kilo lift to chin test, during test day 3. It was carried out indoors on a level surface. During the test, the test subject wore his/her own tracksuit trousers, tracksuit top and trainers, as well as working gloves and firefighting jacket. Every firehose basket was weighed and its weight adjusted, by the addition of weights, to 18.7 kilos.

Preparations consisted of marking a 25-metre line on the floor. Two firehose baskets big enough to take double wide-gauge hose were placed with the firehose basket handles alongside the starting line. Before starting, the test subject gripped the carrying handles for the firehose baskets, one in each hand. At the starting signal, two firehose baskets were moved 50 metres (2 x 25 metres). One firehose basket was left with its rear edge behind the starting line. The second firehose basket was moved a further 50 metres (2 x 25 metres) and left with its rear edge behind the starting line. The test subject moved 100 metres (4 x 25 metres) without the firehose baskets. After that, two firehose baskets were moved 150 metres (6 x 25 metres). One firehose basket was left behind the starting line while the other was moved a further 50 metres (2 x 25 metres). Finally, the test subject moved 200 metres (8 x 25 metres) without firehose baskets. The whole exercise was repeated three times without a break or rest. The time taken for the exercise was recorded in seconds.

Summary of results of simulated job operations

In every one of the individual test operations, there are individual women who perform better than individual men. Nevertheless, the results of the men tested overall are considerably higher than the results of the women tested. As a group, full-time firemen (men) performed best in all exercises, but in some tests the other categories of men produced equivalent results. A number of individual women performed better than men in some job operations, but assessed as groups, part-time firemen (women) and non-firemen (women), above all, found it difficult to measure up to the men's levels of results. In the ceiling breach test, the category full-time firemen (women) achieved equivalent results to those of all men other than full-time firemen (men). The same applied to the drag dummy and carry firehose basket across country tests. The hardest test operation for women emerges as stair climb with firehose basket, in which women found it difficult to produce the same level of results as all categories of men.

For more information on results of tests for simulated job operations, see *"The Physical Capacity of Firemen: Report 3 – Physical limit values (2011)"*, page 53 et seq.


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Physical tests

The physical tests were performed with the same individuals (128 persons) as for the simulated job operations. The tests have been developed to closely represent the overall physical demands to which firemen are exposed. They are also designed in order as a whole to cover the physical requirements that are posed by the most commonly occurring job operations. In a similar way as for the simulated job operations, descriptions of the exercises follow below. Finally, a summary is presented of the performance data for the different test subject categories.

Grip strength

The test was performed with the test subject standing with a straight arm hanging alongside the body. The test subject himself/herself set the size of the hand grip in the "Grip-D" tool so it felt comfortable. Three attempts were made with each hand. The best result for each hand was recorded. In the processing of the results, the best one for the poorer hand is used.

Rowing 500 metres

The test was carried out after 10 minutes' warming up on an exercise bicycle and 5 minutes of light rowing at any chosen resistance. The test subject rowed 500 metres as quickly as possible at the highest resistance (10). Time in seconds and output in watts were recorded.

Bench press

This exercise started 30 minutes after the rowing test and was performed with the test subject lying on a bench with a barbell weighing 30 kilos. The test subject was able to choose whether to place his/her feet on the floor or on the bench on which he/she was lying. The location of the hands on the barbells was slightly wider than shoulder width. No bending or rebounding from the chest was allowed. The movement started with extended arms, the barbell was lowered to the chest and then raised again until the arms were extended again. The test rate was 25 completed lifts per minute. The test was repeated until exhaustion and the number of lifts recorded. Lifts performed at a rate other than the designated one were not counted.

Standing long jump

The jump was performed indoors, feet together, in a sandpit. The test subject started the jump with his/her toes behind the back line of the take-off board. The length of the jump was measured from the edge of the take-off board to the rear edge of the place of landing. Arm movements were permitted. The longest jump out of three was recorded.

Running 3,000 metres

The test was conducted on an indoor running track after 10 minutes' warming up in the form of light running at a pace chosen by the test subject. The running test was conducted in groups of no more than 10 individuals. The time for completion was recorded. Two results from this test are reported. One was time in seconds, the other time in seconds per kilo of body weight.

Lift to chin

The test was performed with both hands gripping the bar. The movement began with the bar placed at a height level with the front of the iliac crest (with arms slightly bent); the bar was then lifted to the chin and then lowered again. The test rate was 30 completed lifts per minute. The test was repeated until exhaustion and the number of lifts recorded. Lifts performed at a rate other than the designated one were not counted.

15 kilo lift to chin

The test was performed in exactly the same way as the 7.5 kilo lift to chin test.

Summary of results of physical tests

The largest differences between the genders in terms of the performances of the categories were in grip strength and rowing, in which all groups of men performed better than all groups of women. The least difference between the genders was observed in lift to chin and running.

When the running test was measured in seconds, the results for the women were in many cases equal to those of the men. Full-time firemen (women) ran as fast as full- and part-time firemen (men). Part-time firemen (women) also produced equivalent results to those of groups of men other than full-time firemen. However, when the running test was instead measured in seconds per kilo of body

weight, a different picture emerged. In that case, all groups of men performed better than all groups of women. The results of the 3,000 metre running test, reported in seconds per kilo of body weight, proved to show a stronger correlation with the performance of the job operation. This applies to all job operations for women and to four out of the five job operations for the category of men. As far as the lift to chin test is concerned, the similarity of performance between the genders was greater at 7.5 kilos than at 15 kilos. At the lower weight, full-time firemen – both men and women – performed equally. However, at 15 kilos, full-time firemen (men) achieved better results than all categories of women. In the bench press test, full-time firemen (women) were as strong as non-firemen (men). In the standing long jump test, full-time firemen (women) produced better results than other women. Groups of non-firemen (women) produced relatively similar results in all tests.

For full details of the results of physical tests, see *"The Physical Capacity of Firemen: Report 3 – Physical limit values (2011)"*, page 44 et seq.

For details of recommended limit values, see the diagram on page 36.


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Summary of physical limit values

The calculation of physical limit values is based on the correlation between performances in tests and simulated job operations. What are termed threshold values were identified in the study. "Threshold" is defined as the point at which the performance below a particular level in an individual test (threshold value) may result in the job operation taking longer to complete. A range of different statistical methods were used to develop the model of physical limit values (see next page). Where it was not possible to identify thresholds, i.e. a better performance in a physical test signifies a better performance in the job operation, a separate statistical method of calculation was used. Together, these methods generated recommendations for upper and lower limit values for the physical tests.

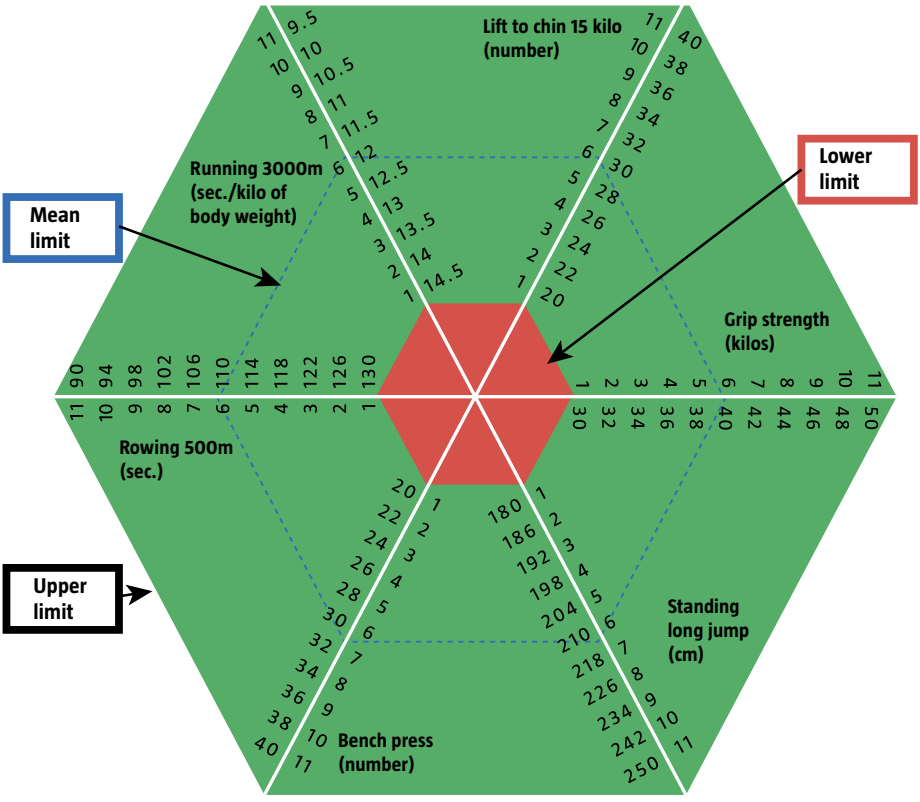
The model comprises a graduated scale (from 1 to 11 points) for each individual physical test, employing statistical analyses of all tests. On that basis, an average physical limit value was calculated (6 points). All physical tests comprised by the model had to be completed, and the overall performance totalled up (total points).

The physical limit values are shown on three levels:

- **Lower limit value** represents the minimum permissible value (1 point).
- **Upper limit value** is 11 points. Even if the performance is better than the result that corresponds to 11 points, no additional points are awarded.
- **Mean limit** is the average result from all tests comprised by the model (6 points).

The objective for overall physical capacity is to acquire 36 points from the six tests, allowing lower results from certain tests as long as the shortfall is offset by better results from other tests.

In the study, the recommended value for acceptable overall physical performance for a newly recruited fireman is 36 points. Because no guidelines have been set as to how long an operation should take, the limit values established by the model should be regarded as guideline values.



Physical limit values.
Source: "The Physical Capacity of Firemen: Report 3 – Physical limit values (2011)", page 108.

The report describes the points totals and the values in terms of "fail" and "pass". Another approach may be to regard lower and upper limit values as frameworks and objectives in the sense that a lower limit should be regarded as the preferable minimum value and an upper limit as one preferably to be achieved.

In the study presented here, 97 percent of the men and 33 percent of the women achieved the lower physical limit value (the result that in the physical tests should according to the study be regarded as the preferable minimum to be achieved). The project report (Report 3) does not state the number of individuals who achieved the level of "pass" (minimum of 36 points). On the other hand, research team leaders at Winternet had analyzed the results, which are reported in this document in tabular form.

Percentage of "fails"

Through the model developed for physical limit values, more men than women achieve the various levels for the particular test. The percentages of fails for individuals and categories in the model for physical limit values are indicated in the table below.

TYP OF TEST	POINTS LIMIT LEVEL	FAILS, WHOLE CATEGORY %	FAILS, MEN F-TF/P-TF/NF %	FAILS, WOMEN F-TF/P-TF/NF %
Grip strength	1	9	0/0/0	0/17/35
Rowing 500 m	1	2	0/0/0	0/9/4
Bench press	1	32	0/0/0	18/70/88
Standing long jump	1	18	0/5/5	6/44/44
Running 3,000 m	1	13	0/0/0	0/29/46
Lift to chin, 15 kilos*	1	7	0/0/0	0/13/25
Grip strength	6	43	0/5/5	65/83/100
Rowing 500 m	6	30	5/0/10	12/74/67
Bench press	6	50	10/5/38	41/91/100
Standing long jump	6	38	0/14/14	29/76/83
Running 3,000 m	6	34	5/5/5	35/78/77
Lift to chin, 15 kilos*	6	32	0/0/8	18/65/75
Grip strength	11	61	10/24/32	100/100/100
Rowing 500 m	11	92	76/86/91	100/100/100
Bench press	11	64	10/24/62	82/100/100
Standing long jump	11	80	52/67/59	100/100/100
Running 3,000 m	11	80	40/71/68	100/100/100
Lift to chin, 15 kilos*	11	52	0/15/31	35/96/92

*Percentage of fails in the six types of test, as well as the different test categories (*Only 87 individuals carried out the 15 kilo lift to chin test).*
Source: "The Physical Capacity of Firemen: Report 3 – Physical limit values (2011)", page 109.

The relatively high proportion of fails may beg the question of whether a person with a result of fail is actually capable of carrying out the operational duties of a fireman. The answer is probably yes, partly against that background that all test subjects actually completed the job operations. On the other hand, physically demanding job operations are likely to take longer than by a person meeting the limit value requirements.

Percentage of passes

Of the 128 individuals who participated in the study, 84 completed all tests in the model described on page 36. Half of those did not achieve the "pass" level. If the non-firemen test subjects are discounted, there were still just half of all full- and part-time firemen who achieved the "pass" level. Just over half of the women full-time firemen achieved the level of pass. All men full-time firemen achieved the 36 point level, but none of the non-firemen women did.

	NUMBER OF TEST SUBJECTS	NUMBER WHO ACHIEVED 36 POINTS	PERCENTAGE
Full-time firemen, men	9	9	100
Full-time firemen, women	17	9	53
Part-time firemen, men	13	12	93
Part-time firemen, women	21	1	5
Non-firemen, men	13	12	92
Non-firemen, women	11	0	0
Total	**84**	**43**	**52**

"Pass – physical capacity" (36 points) for the test subjects who completed all tests in the model for physical limit values (the table above is based on data from the research group not included in the final report).

Conclusions of the report

According to the model for physical limit values, a lower capacity in a particular area of physical testing may be balanced by a higher capacity in another. In that way, individuals with different results from specific tests could nevertheless achieve equivalent performances during a complex work operation. All-body performance as well as psychological characteristics (not investigated here) therefore have to be taken into account in assessing the capacity of firemen to perform a particular job operation. As a result of this approach, physical limit

values should therefore be established on the basis of a graduated scale allowing a certain degree of compensation. Aggregation of a number of physical tests also increases the chances of being able to accurately predict how quickly a certain individual will be able to perform a specific task.

Within the rescue services, there are a number of specific job operations that are extremely physically demanding, but that, on the other hand, rarely occur. In these cases, it is not reasonable to start out from the recommended limits for general physical capacity on the part of fireman. Setting limits for physical capacity in the way proposed here means that certain individuals will not achieve the limit value set by the model. At the same time, individuals who achieve the limit value according to physical tests may nevertheless find it difficult to perform specific job functions within the rescue services. The work involved is complex and physical capacity is only one of several factors affecting performance.

Three opinions on how the results can be used

High time to re-examine the work environment issues:

Methodology and technology development in the MSB in-tray

Lena Brunzell
Administrator, Equal Opportunity and Diversity.
Project Manager: "Action programme to promote equal opportunity and diversity in municipal health and safety issues".
Rescue Services and Crisis Management Development Unit, MSB.

The rescue services today lack unified national requirements for physical capacity in recruiting firemen. This absence of a coordinated structure was one of several factors behind MSB's initiative to establish the study presented here.

"Today, every one of the fire and rescue services has its own particular recruitment procedure, and there's every reason to strive for a more unified view on the requirements. Different levels of requirement are unsatisfactory for several reasons," says Lena Brunzell, MSB.

"An SMO trainee seeking work may be approved by the fire and rescue service in one location, but refused in another. Standard requirements would make it easier for all parties," she argues.

Strength and fitness tests are traditionally central issues in the recruitment of firemen, but perhaps should not be so all-prevailing.

"We have received indications that the physical tests have led to a certain level of rejection of women applicants, which is cause for concern."

This fact has raised the question of whether the requirements have been set higher than is demanded by the profession.

"If that's the case, then there's a lack of fairness. Simply to recruit on the basis of physical performance is regrettable," says Lena Brunzell.

The new study into physical limit values is a step in the right direction. But more research, including into future methodology and technology development, is needed. As far as Lena Brunzell is concerned, the findings of the study could be used to beneficial effect as a pedagogical model in the rescue services.

> Technical aids already exist that simplify and lighten the workload of firemen, but for some reason they are used to an extremely small extent.

"The limit values for different functions make excellent target values in the training of individuals.

By training under this model, firemen, men and women alike, obtain an indication of their individual strengths and weaknesses.

"This provides scope for more individual, needs-based training, for example, in grip strength for one individual and lifting strength for another."

The task of driving forward methodology and technology development now lies in the MSB in-tray. The job of a fireman is hard. It demands good strength and fitness, but it may well be that a little too much focus is placed on the individual's physical strength," suggests Lena Brunzell. Teamwork and the collective strength of the group are important here, and, last but not least, that underrated factor: technical aids.

"Technical aids already exist that simplify and lighten the workload of firemen, but for some reason they are used to an extremely small extent. Tradition, habits and routines are among the possible reasons."

In addition to standardized physical tests and further development of technical aids, Lena Brunzell would like in future to see a closer focus on the overall working environment of firemen. Strong firemen become worn out prematurely, too, but changes in attitude towards the way the profession is practised are needed if the necessary changes are to come about, she believes.

"A better work environment benefits everyone, and it's MSB's responsibility to drive developments forward in that direction. We need to move from words to action."

Flexible recruitment and more broadly-based merit ratings

Marcus Cato
Administrator,
Swedish Association of Local Authorities and Regions

The rescue services have delegated their recruitment activities too far down in the organization. That's the view of Marcus Cato at the Swedish Association of Local Authorities and Regions. His hobby-horses centre on flexibility versus predictability in the recruitment of firemen. In his view, far too much focus is today placed on physical tests..

"More centralized management of recruitment issues would undoubtedly lead to a more broadly-based approach as to what merits are relevant to the work of firemen.

By overrating physical strength, we have missed the goal," says Marcus Cato. He points out that the municipal fire and rescue service of the future also has a mission to educate, inform and communicate. Not just to fight fires.

"Sometimes the job needs raw strength, but today the requirements are set extremely high. In some cases, merits other than physical strength are not valued."

One important question to ask is whether certain physical characteristics may be balanced by other qualities. Marcus Cato is keen to play down the importance of the current report as the only guidance in recruitment within the rescue services. Instead, he emphasizes the importance of a holistic approach. As part of this way of thinking, he uses Winternet's hexagonal model as an example, although employing criteria other than physical strength. In Marcus Cato's version, the six physical characteristics are replaced by an equal number of new components, namely physical strength, firefighting training, other training, motivation/lifestyle, practical experience and cultural background. A hypothesis that clearly highlights the physical side as part of the individual's complex and accumulated skills.

"It's about moving the focus from specific sets of muscles to all-body load, with mental and intellectual capacity being included in the assessment.

The next step is to look at the overall merit rating of the entire workgroup: all-body load per person per group, mental capacity and social capability per person per group.

"It's a strength if the individuals in a team are diverse. A heterogeneous group is more creative because of the mix of experiences. Culturally, too, the rescue services need a clearer mix."

Marcus Cato's holistic approach to recruitment is perhaps mainly applicable to large and medium-sized municipalities. They receive so many applicants that selection situations arise.

"But when a smaller fire station or part-time fire and rescue crew are inviting applicants, there may be no-one standing there when they open the door. Or possibly one applicant … Or at best two."

"This means that it is a major challenge to identify arrangements for designing any common recruitment system for the whole country. If it is possible in the first place."

"Irrespective of whether a common system can be established or not, one important step forward for the future is the methodology and technology development that is currently underway. Here, the MSB is an important actor that could play an important role," says Marcus Cato.

It's about moving the focus from specific sets of muscles to all-body load, with mental and intellectual capacity being included in the assessment.

Physical strength not the only factor in recruitment:

Local needs must decide

Anders Engblom
Chairman of the national council representing the rescue services (PACTA). Chief Fire Officer (CFO), Östra Blekinge Joint Fire and Rescue Service.

The action plan for the rescue services clearly expresses the ambitions of the municipalities for the objectives of the activities. To realize these ambitions, a number of competencies and skills are required.

"It's up to every individual employer to determine the relevant requirements before each particular recruitment exercise," says Anders Engblom.

He goes on to assert that what decides who obtains a job is a balance of competencies and skills.

"It's not possible to set certain conditions, for example physical recruitment requirements, at central level. In the final analysis, it is the local fire and rescue service that decides who is to be employed."

On the other hand, it is useful to receive guidance during the recruitment process in the form of national studies and assessments.

Physical capacity has traditionally played an important role in the rescue services. Each individual bears a major responsibility for maintaining his or her physical status, while the employer's responsibilities are dictated by work environment legislation. But if physical capacity is regarded as the sole criterion of selection, the horizon has been sharply narrowed," argues Anders Engblom. In addition, he does not deem it possible to establish who is suitable for the profession of fireman by measuring capabilities. The process is more based on a complex profile of requirements devised by the employer concerned.

What I don't see is an analysis of the implications of the findings of the study. Especially if the data reported is expected to apply throughout an employee's whole career as a fireman.

"But it would be valuable for the MSB, as the formal training agency for firemen, to establish a perception of what requirements are reasonable for the demands to which firemen are subject. If only to adapt its training programmes and prepare students for what their profession will demand.

In Anders Engblom's eyes, the limit values in the report presented on this occasion are set at surprisingly high levels.

"What I don't see is an analysis of the implications of the findings of the commission. Especially if the data reported is expected to apply throughout an employee's whole career as a fireman."

"From that point of view, the implications in terms of labour law are of particular interest."

In his opinion, it is time that the industry carried out a study of future needs in terms of manning, recruitment, functions and training. In that context, physical requirements represent one of several elements.

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