6. Assessing and controlling physical activity

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Summary

Physical activity has many healthy effects, both physical and mental, and is therefore used both for the prevention and treatment of disease. To make the right prescription of physical activity possible, and to help individuals find the right load and evaluate prescriptions issued, reliable methods and measurement instruments are necessary. This chapter describes various measurement methods, their reliability and limitations, and how they can practically be used in connection with the prescription of physical activity.

Assessment of physical activity

The outcome of a physically active lifestyle is that different bodily functions are improved, such as aerobic fitness and strength. Other functions and parameters can also be affected, such as body weight, waist circumference, body composition, blood pressure and lipoproteins. The same applies to mental health, where conditions of depression and anxiety can be reduced through physical activity. Besides these effects, the actual physical activity or frequency of exercise can be measured or assessed with different instruments. In this chapter, the concept of assessment is consistently used instead of measurement since certain measurements are direct while others are indirect and are based on the participant's own assumptions (1, 2).

Physical activity is another word for bodily movement that results in increased energy expenditure. It is also a complex behaviour. Accordingly, physical activity can be assessed in the form of energy expenditure or as a behaviour. The components of the activity that have shown a correlation with health are intensity, duration and frequency. For health-enhancing effects (3, 4), the activity is recommended to be carried out at an *intensity* that is at least moderate, for a combined time (*duration*) of at least 30 minutes and preferably every day (regular *frequency*). A few different methods are described below that can be used to assess the degree of physical activity.

Questionnaires

Questionnaires for assessment of physical activity are the most common method and there are currently hundred of variants available (2, 5). The most basic only ask about the individual's exercise habits and offer pre-determined responses on a 3–5 degree scale. The more advanced ask exactly what has been done and for how long, and maybe even how often the individual has been physically active during a certain period of time (the past week, month, or the like). Most questionnaires ask about the degree of exertion, which is affected by the individual's capacity. It is likely that the better aerobic fitness and strength the individual has, the easier the activity is perceived to be. In addition, the individual's body weight is of significance since it costs more energy to carry around more weight and the activity is then perceived as more strenuous.

To calculate the energy expenditure from questionnaires, the given activities are weighted with an energy expenditure measure for the activity. Metabolic equivalent (MET), or a multiple of the oxygen uptake at rest, is often used (6, 7). Resting corresponds to 1 MET and calm activities 1–3 MET. Activities of moderate intensity can vary between 3–6 MET and activities that entail a high level of exertion are over 6 MET.

On prescription forms for physical activity, there is a question where the prescriber can obtain a rapid view of health-enhancing physical activity. It asks: *How many days in the past week have you been physically active with at least moderate intensity during a total of 30 minutes per day?* It is followed by the same question, although with a time perspective of "a regular week". The question has been method-tested in a project at the Karolinska Institutet (8).

However, if exercise or training habits are asked about, it should be noted that the respondent only assesses parts of the total physical activity completed. These questions most often show a high degree of reliability and validity, since it is easier to remember what is done regularly and with a higher intensity (1, 2, 9). It is also exercise that has shown the strongest association to achieved health effects. If exercise is prescribed, then it is also exercise that should be evaluated. However, if everyday activities are prescribed, they cannot be assessed with questions about exercise.

As presented by many studies, it has often been difficult to compare physical activity levels within a country, but especially between countries since different methods have been used. This has led a group of international researchers to develop a method that measures all health-enhancing activity and is standardised and can be used internationally. The International Physical Activity Questionnaire (IPAQ) was developed and method-tested at the beginning of the 2000s (10, 11) and is now a national and international standard in several countries and organisations (WHO, EU). This instrument has also been method-tested in Sweden, where the results indicated that its reliability and validity is on a par with other subjective instruments (12, 13).

Diaries

To determine the total energy expenditure and also obtain a measure of how the activity is divided over the day, diaries can be used (2, 14, 15). The journal should include what has been done based on given examples with a certain time interval (every 5th or 15th minute). These have shown a high degree of concordance with the total energy expenditure, but are time-consuming for the participants, which means that they are seldom useful in large-scale studies.

Movement sensors

To escape from the systematic errors that self-reports of physical activity entail (it is difficult to remember the degree of exertion, over-reporting is common, etc.), objective methods are used. The instruments that can assess activity directly are *step-counters* and *accelerometers*.

Step-counters provide a rough measure of the activity and their use can be beneficial in interventions so the persons themselves can follow their activity development since direct feedback to the individual is possible. It should be noted that there are many different brands of varying quality. Depending on sensitivity and so on, the variation in the number of steps can be more than 20 per cent. A good step-counter should be method-tested in terms of reliability and validity, have a cap, not have a filter function and should be robust. The sensitivity should be 0.35 G, which means that it is sensitive to natural human movement (16). The disadvantage of step-counters primarily lies in the fact that they say nothing about intensity. This means that if a person walks 100 meters, the step-counter will register approximately 110 steps, while it only registers approximately 70 steps if the person runs.

Figure 1. Example of an accelerometer and how it is attached to the body.

Accelerometers are more advanced instruments, which also means that they are more precise. They measure acceleration in one or more orthogonal planes with the help of either a mechanical pendulum or a digital function. Acceleration is a direct measurement of body movement and the higher the acceleration, the greater the intensity. Besides total physical activity, accelerometers can also provide a measure of intensity, duration and frequency, that is to say the pattern of the activity. Another strength that the accelerometer has is that it can assess inactivity and sedentary behaviour. However, accelerometers are more costly than step-counters, but they are preferable if greater precision is desired. A good accelerometer should be method-tested and easy to wear (17, 18).

With accelerometer technology, a time period can also be set over which the activity should be summarised (a so-called epoch). The shorter the time period, the more precision is possible. For adults, the time period of one minute is most often used and for children 10–15 seconds. In addition, newer models of accelerometers manage to store data for a longer time, which means that measurements can be carried out for months if desired, but the individual's activity is usually measured for a week. Accordingly, an accelerometer produces enormous amounts of data. If a 15 second time period/epoch is used, there will be four points per minute, times 1,440 minutes per day, times seven days per week, resulting in approximately 40,000 data points per individual. An extensive post-treatment of collected raw data is needed before a comprehensible description of an individual's physical activity can be made. The advantage of using accelerometers often outweighs the disadvantages, however.

Both step counters and accelerometers are insensitive to activities that take place with the upper-body or activities such as swimming and cycling. In spite of this, they provide a good view of overall activity and for accelerometers also of how the activity is divided over the day. Studies have shown that approximately 90 per cent of the time is spent sitting, standing and walking, that is to say that the persons studied carry out activities that the movement sensors can register.

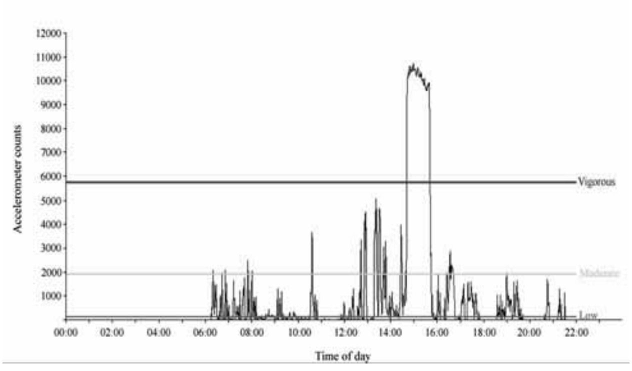

Figure 2. Example of how a day can look, registered with an accelerometer.

Heart rate monitoring

One way of indirectly measuring physical activity is to use heart rate monitoring, such as with a heart-rate monitor. With the help of a sensor around the chest and a receiver in the form of a watch, the pulse can be continuously monitored. The pulse has a virtually linear relationship to exercise intensity (primarily aerobic work – with oxygen). Several models of heart-rate monitors have the possibility of storing data and can be connected to a computer for processing. This method makes it possible to measure intensity, duration and frequency. It also provides a good measurement of the total energy expenditure (19). Heart-rate monitors are frequently used at the individual level to find the individual's optimal exercise intensity based on current aerobic capacity.

Combination of methods

New instruments are constantly being developed to assess physical activity. The most modern, which are also more advanced and expensive than the aforementioned, combine several methods and technologies. ActiReg is an instrument that combines body position and movement separately or in combination with heart rate. ActiReg classifies the activity's energy expenditure in the categories easy, moderate or very strenuous. ActiHeart is another instrument that combines accelerometry and heart rate. In this method, the accelerometry weighs the heaviest at low intensity, while heart rate weighs heavier at high intensity. This way, the measurements are weighted to make the calculation of the completed physical activity more precise. New products combine accelerometry and GPS data (Global Positioning System) to also weigh in movements/distance in the calculations.

Determination of sedentary behaviour

A person who follows the health-enhancing recommendations, or the recommendations for strength and aerobic fitness, can also be sedentary for a significant part of the day. In other words, it is possible to periodically both be highly active and sedentary "at the same time" (20). Physical inactivity (can be defined as not fulfilling the recommendation) and being sedentary can thereby be viewed as two risk factors, which both need to be studied together and independent of one another.

To determine the degree of sedentary behaviour, several different types of questions have been used, such as about the time that children and young people spend in front of the TV or computer. These questions are misleading unless the total activity is also taken into account. Of the objective instruments, accelerometers and heart rate monitoring can provide an illustration of all so-called sedentary time, as well as active time. Step-counters, however, cannot say anything about time spent sitting still. Questionnaires like the IPAQ can also provide an illustration of this behaviour.

Assessment of aerobic fitness

Aerobic fitness can be evaluated with maximal or submaximal tests on ergometer cycles, stair machines or treadmills (21). Maximal tests should not be carried out on risk individuals other than under controlled forms, such as in a physiological laboratory. However, submaximal tests are very well suited to clinics and in prevention and promotion work. All submaximal tests build on the same principle, that is to say that there is a linear relationship between exercise intensity and pulse. With the help of the maximal heart rate, which can be calculated by decreasing the value 220 (for men, 225 for women) by the individual's age, and a set exertion, such as through a standardised resistance on a test cycle, the maximal oxygen uptake can be calculated. The most common submaximal method in Sweden is Åstrand's cycle test (22).

All submaximal aerobic fitness tests have a minimum of 10–15 per cent method error and can be used on the individual level before and after an intervention if the conditions are standardised. The systematic errors are largely due to the assumption made about the individual's maximal heart rate (220/225 – age only gives a rough estimate of the maximal heart rate), but also to full stroke volume not being achieved and handling error, such as the cycle not being calibrated or the pulse watch not being applied properly. It should also be mentioned that submaximal aerobic fitness tests have low reproducibility compared with maximal tests.

Another way of estimating the aerobic capacity is to use the RPC scale (Rating of Perceived Capacity) (23, 24). The scale should be seen as a complement to aerobic fitness tests and be used to provide a fast, approximate estimate of fitness in clinics where neither time nor equipment is available for aerobic fitness tests. The scale is based on various activities connected to metabolic equivalents (MET). The scale starts at 1 MET (which corresponds to the oxygen uptake at rest) and ends at 20 MET for men (which corresponds to an aerobic fitness value of 70 ml/kg/min) and 18 MET for women (which corresponds to an aerobic fitness value of 63 ml/kg/min) (figure 3). A qualified estimate of aerobic fitness is obtained by the individual assessing the most strenuous activity and corresponding MET value that the person in question believes he or she can maintain for 30 minutes. Based on the estimate, the aerobic fitness figure (maximal oxygen uptake in ml/kg/min) can then be calculated by multiplying the number of MET that the individual has given by 3.5. In addition, oxygen uptake is obtained in litres per minute by multiplying the aerobic fitness figure by the individual's body weight. To further increase the estimate's precision in research, for example, an age correction can be made. However, this is not necessary in clinical practice.

Estimation of perceived capacity – RPC (Rating of Perceived Capacity)
Can you do the following for half an hour or more

1	Sit
2	
3	Walk slowly
4	
5	Walk at a normal pace/cycle slowly
6	
7	
8	Jog/cycle
9	
10	Run
11	
12	Run fast/cycle fast
13	
14	
15	Run very fast
16	
17	
18	Do aerobic exercise at an elite level (women)
19	
20	Do aerobic exercise at an elite level (men)

Figure 3. RPC scale.

There is strong evidence that performance capacity in the form of maximal oxygen uptake has a dose-response relationship with health and that oxygen uptake can rapidly improve in an untrained individual when he/she begins exercising. But determining performance capacity does not provide an illustration of whether the individual is active or not overall, since genes also control performance capacity. The individual can have a high capacity without being physically active, vis-a-vis a low capacity and be physically active. The higher the capacity, the more space there is to maintain a high level of energy expenditure. Therefore, it is also important to measure capacity (in the assessment and control of physical activity). If an intervention aims to increase the total energy expenditure, a method that can measure it must be used, however.

Assessment of strength

Strength can be assessed with both standardised methods for static or dynamic muscular endurance and strength such as with the so-called 1 RM method (one repetition maximum, as described below), which gives a measure of dynamic strength. The assessment can take place based on normal values, if they exist, but also with the help of the "healthy side", the quality of the movement and the Borg rating (which is explained in detail under the heading "Assessment and control" further down in the chapter). Regardless of the test method, the experimenter must be aware that different factors affect the test result. Among these are a standardised test procedure as well as anatomical, neurological, psychological, mechanical and muscular factors.

Among the standardised methods are Sörensen's test for static muscular endurance in back stretches, Svantesson's test for dynamic muscular endurance in the calf muscles and UKK's (Uhro K Kekkonen Institute of Sports Medicine) test battery for health-related fitness. The UKK tests include strength, endurance, balance, motor control, flexibility and aerobic fitness (25).

With the objective of optimising the load in strength training and to be able to evaluate if performed strength training has had the desired effect, dynamic strength can be measured by finding the load that the individual can only manage to lift once – 1 RM. To test the weight that corresponds to 1 RM, various approaches can be used. The most common procedure is to take a suitable weight and test how many times the individual can manage to lift it through the full range of motion at the same speed and under control (preferably not more than 10 times since the table is only reliable up to approximately 10–15 repetitions). Then, 1 RM is calculated based on figure 4. This approach is the safest from an injury perspective. Another alternative is to try to find the 1 RM weight, that is to say the weight the individual can lift once. However, this entails some risks of both overloading and improper execution. The measured strength then forms the basis to guide the strength training towards the desired objective, considering load, sets, repetitions and frequency.

Number of repetitions	Per cent of max.
1	100
3	90
5	85
7	80
10	70
≈ 15	60
≈ 25	50
≈ 50	30

Figure 4. Repetition maximum.

Assessment of body composition

An outcome of regular physical activity and good eating habits is that the body measurements return to the normal variation. Body measurements can thereby function as an indicator and an evaluation instrument in the prescription of physical activity. A few basic body measurements are presented below.

Height, weight and BMI

Correctly measuring the height of children and adults is seldom problematic. At adult age, height is also relatively stable, although aging entails some height reduction. Of course, the yardstick used to measure height should be checked and no measurement taken with shoes. In studies of the truthfulness of self-stated height in surveys and interviews, quite a few errors have been shown to exist. For example, the height given by short men is often taller than the true height, and the elderly are often unaware of their reduced height.

The weight indicated or measured can also be encumbered by errors. Scales used should be calibrated and be of good quality. The person to be weighed should be sparsely clad. In self-stated weight, a number of problems also arise, where overweight people indicate a lower weight than their true weight, underweight people state a higher weight and so on. The differences between self-stated weight in surveys and in interviews and the true weight is larger for teenagers, those with little education and the overweight.

When the body measure of BMI (Body Mass Index) is to be calculated, that is to say the weight in kilograms divided by the square of the height in metres, a number of problems arise if data is based on self-reported height and weight. This means that BMI data from this type of study cannot at all be compared with BMI data based on measured height and weight. It is notable that BMI does not differentiate weight from muscle and from body fat. Many muscular elite athletes would therefore be classed as overweight if only BMI were used at the individual level.

For adults, there are well-defined limits for what is considered to be overweight and obese (BMI ≥ 25–29.9 = overweight, BMI ≥ 30 = obesity). For children, there are a few different limits set to define overweight and obesity at different ages where the most commonly used are Cole's cutoff points (26).

Waist circumference

The waist circumference is measured with the help of a tape measure in a standardised manner. It is measured after a relaxed exhale, approximately two centimetres above the navel, which is just under the lowest rib. The individual can learn how to measure and follow his or her own development. In addition, there are some recommended guidelines where women who have waist circumferences over 80 cm are at greater risk and over 88 cm much greater risk for cardiovascular disease. For men the limits are at waist circumferences of 94 and 102 cm, respectively. This applies to ethnic Caucasians. For other ethnic groups, such as persons from Asia, lower cutoff points apply. Hip measurement is also of major interest; in recent years, it has been shown that stout hips can function as a protection against hip fractures and have a correlation to less risk of cardiovascular disease among women (27). To calculate the waist/hip ratio, the waist measurement is taken as above and the seat measurement measured at the broadest point. The waist circumference divided by the hip circumference should not exceed 0.85 for women and 1.0 for men.

Body composition

To find out the distribution between fat and non-fat (which can be muscles, bones, fluid), more advanced methods can be used. Some of these are used at exercise facilities in consultations and for research purposes.

Skin-fold measurement is a relatively simple method where the experimenter measures subcutaneous fat at standardised locations with the help of a calliper. With the help of tables or formulae for age group and gender, an approximate fat percent can then be calculated for the particular individual (28).

Bioimpedance is a method based on muscles conducting an electric impulse better than fat due to the higher water content. The most valid bioimpedance equipment measures through the entire body, leg to arm. The most used methods, but with the worst reliability, are those that only measure arm to arm or leg to leg (28).

More sophisticated methods are found in research contexts and are often used to validate basic methods or to evaluate research projects. Among these are the water method, underwater weighing and air displacement technology as well as DXA (Dual Energy Xray Absorptiometry). These methods are often expensive and require costly equipment and training (28).

To keep in mind in an assessment of physical activity

The elderly

For the healthy elderly, the same principles for assessment and evaluation apply as described above. For example, in national living habit studies, the same question about exercise habits in leisure time is used for all adults ages 18 to 84 (29). To more specifically assess the degree of physical activity among the elderly, the method-tested Activity Scale is often used and is recommended (30).

Persons with obesity

Among overweight persons (BMI 25–29.9) and the obese (BMI 30–35), the instruments described above can be used. Those with severe obesity (BMI over 35) have difficulty moving at all and everything they do costs a great deal of energy since they carry a great deal of weight (31). Studies of energy expenditure among the severely obese have shown that some use up to 90 per cent of their maximal capacity when walking at a self-chosen speed (32). There can also be other obstacles in the form of joint problems and incontinence that affects the perceived exertion and degree of activity.

If objective instruments are used such as step-counters, they must be set in such a way that allows the registration of vertical movement. Otherwise, a risk exists for them becoming stuck in the “folds” and not being exposed to any vertical acceleration. Moreover, the obese often perceive it as unpleasant and warm to wear the activity monitor.

An outcome of physical activity and exercise can be that daily functions improve. This means that functional tests, such as standing up unassisted and being able to tie one’s shoes, can function as an indicator and evaluation instrument in the prescription of physical activity (33).

To keep in mind among persons on medication

Certain drugs, such as beta-2 stimulators, which are common for asthma, and beta blockers, which are common for cardiovascular problems, affect systems (such as heart rate) in the body, which in turn can affect the assessment of aerobic fitness and physical activity. For these individuals, movement sensors (step-counters and accelerometers) are recommended ahead of heart rate monitoring. In aerobic fitness tests, perceived exertion (34) should always be used in combination with heart rate.

Children

Children have an entirely different movement pattern than adults, and in one minute, can be active with a high level of intensity, have time to rest and then be just as active again. Nor do children think or remember physical activity in the way that adults do, which makes it nearly impossible to ask children how physically active they are. Only assessning how often children participate in some sport or physical education gives a restricted view of the total activity.

At a national level in Sweden, the WHO instrument HBSC (Health Behaviour in School Children) has been used to measure the health habits of children and young people (35). In the instrument, young people are asked if they have been physically active for at least an hour five times a week or more often. The responses do not give any information about which activity was done or how strenuous it was, but a pretty good view of dose and regularity. The question is method-tested by the WHO (36), although not specifically in Sweden. Other method-tests of more specific questions like IPAQ have shown that children and young people do not understand the concepts, do not perceive time in the same way as an adult and therefore have difficulty in answering them.

To avoid children's and young people's difficulty in remembering activities, which is largely due to the activity pattern being irregular and more play-oriented, objective assessment instruments are recommended such as step-counters or accelerometers.

Assessment and control of intensity

When prescribing physical activity, it is relatively unproblematic to give and take instructions regarding the physical activity's frequency (how often) and duration (how long). In terms of intensity, it is not as simple. As previously presented in the chapter, a number of methods have been developed to assess how intense work done is and, respectively, many recommendations with regard to how intense the physical activity should be to lead to health effects. For example, it is said that aerobic activity should be carried out at least at a *moderate level*, with an *intensity that gives rise to light breathlessness and sweating*, or be of *average intensity* or a level that *allows conversation*. If a physiologist is asked, intensity is often expressed in terms of a *percentage of the maximal oxygen uptake* (50–65 %) or in a *percentage of the maximal heart rate* (60–75 %) or the age-predicated maximal heart rate. For strength-oriented activities, the recommended intensity is often given in relation to the repetition maximum (1 RM) and in per cent, for example 80 per cent of 1 RM in strength training and 50 per cent of 1 RM in muscular endurance training.

These ways of describing intensity can in practice be difficult to explain (for the prescriber) and follow (for the patient). From a pedagogic perspective, a method that is easy to explain and easy to understand is therefore valuable. A method that has proven to work well both from a scientific research perspective and out in reality is the rating scales designed by the Swedish psychologist Gunnar Borg. In terms of ratings of perceived exertion, Borg's RPE scale (Ratings of Perceived Exertion) is common while strength estimates are preferably made with the help of the CR10 scale (Category Ratio). Both scales are based on verbal expressions that are rooted in a numerical scale between 6–20 (RPE scale) or 0–10 (CR10 scale). The advantage of using rating scales is that the responses reflect a total appraisal of signals from many different parts of the body (37).

A number of different physiological reactions such as pulse, respiratory frequency, sweating and pain from joints and exerted muscles contribute to the total perceived exertion. Exactly how these physiological reactions co-vary and contribute to the perceived exertion is not known, but it can be assumed that some are more generally applicable (such as pulse) while others are more individually related (such as signals from joints and muscles). However, it is known that ratings on the RPE scale grow linearly towards the load increase both in cycle ergometer work and running on a treadmill, just like the heart rate and oxygen expenditure increases when the load increases. A correlation coefficient between 0.85 and 0.99 has also been reported with regard to load and perception increase, as well as subjective perceptions and heart rate or oxygen uptake (37).

The exertion rating is also affected by a number of factors such as age, training status and personality. Although growth against load remains linear from low to high intensity regardless of age, the absolute relationship between heart rate and RPE rating will change. The RPE scale's number variation between 6–20 corresponds to an approximate heart rate variation for a young person between 60 and 200 beats/minute (based on the maximal heart rate corresponding to approximately 220 minus the age for men and 225 minus the age for women). By the maximal heart rate decreasing with increasing age, the relationship to ratings on the RPE scale will change. While a rating of 15 roughly corresponds to a pulse of 150 beats/minute for a young person during cycle ergometer exertion, the same rating for a middle-aged person would correspond to around 130 beats/minute or 110 beats/minute for an elderly person. The advantage of ratings of the degree of exertion are consequently clear since the variation range is maintained to a significantly greater extent than is the case with the heart rate at an increased age.

At the same time, it is known that well-trained persons often underestimate their degree of exertion while untrained persons overestimate it (38). The individual's personality has also proven to affect the exertion ratings. For example, persons with distinct type A behaviour (which is considered to increase the risk of cardiovascular disease) have proven to underestimate their exertion compared with individuals with a lesser degree of this behavioural pattern (39).

Another personality trait that appears to affect the perception of exertion is the individual's locus of control[1], in that those with an internal locus of control show a more accurate rating behaviour compared with those with an external locus of control (40, 41). Within health-psychology research, it is well known that persons with an internal locus of control, who themselves consider that they can affect their health to a high degree, both follow

1. The individual's feeling that it is possible or impossible to influence and control his or her own performance. Athletes with a high level of internal control (internal locus of control) feel that successful performance is most often due to their own ability, such as good preparations and good training, in other words factors that can be influenced. People with a high level of external control (external locus of control) instead more often feel that good performance is due to happenstance, randomness or luck.

prescriptions better and regain health faster than those with an external locus of control (42). However, none of this reduces the RPE scale's reliability, but in the same way that a measured heart rate has to be related to the individual's degree of training and age, the exertion rating must be assessed in terms of likelihood and credibility. If the scale is used to compare the ratings for the same person at different test times (intra-individual comparisons), an effect from the individual's personality plays a smaller role than if comparisons are made between individuals (inter-individual comparisons). Naturally, this is also true of heart rate and oxygen consumption, since we assume that heart rate, oxygen uptake and personality are relatively constant over time (with a reservation for the unavoidable age change with regard to maximal heart rate and any exercise effects).

In the following section, both the RPE scale and the CR10 scale are described as well as how they can be used both for ratings in connection with physical exertion and to control intensity. The latter is particularly useful when physical activity is prescribed and the patient needs to know how intense the activity in question should be.

Borg RPE scale®

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Figure 5. Borg RPE scale®.

For the ratings to show a high degree of reliability, detailed instructions are required so that the patient rates his/her degree of exertion and nothing else. Oral instructions can be worded as follows (34):

> While working, we want you to rate your feeling of exertion, how hard and strenuous it is and how tired you feel. The perception of exertion is mainly felt as fatigue in your muscles, and in your chest in the form of breathlessness or possible pain. All types and levels of physical activity require some exertion, even if only minimal. This also applies if one does light exercise, such as walking slowly.
>
> Use this scale from 6, ”No exertion at all”, to 20, ”Maximal exertion”.

6 ”No exertion at all” means that you do not feel any strain at all, for example, no muscle fatigue, no breathlessness or difficulty breathing.
9 “Very light”. Like taking a short walk at your own pace.
13 “Somewhat hard”. You can continue without great difficulty.
15 It is “strenuous” and laborious. You are tired, but can continue anyway.
17 ”Very hard”. A very strong strain. You can continue, but have to work very hard and you feel very tired.
19 An “extremely” high level. For most people, this corresponds to the highest level of exertion they ever felt.

> Try to be as honest and spontaneous as possible and do not think about what the load actually is. Try not to underestimate or overestimate it. It is important that it is your own feeling of exertion and not what you believe others think. Look at the scale and base your rating on the words, but then choose a number. Use whichever numbers you want on the scale, not just those marking the expressions.
>
> Any questions?

Central and local exertion

In some contexts, it can be valuable to differentiate central exertion (breathing, pulse) and local exertion (the working muscles). This can be the case if the individual suffers from cardiopulmonary problems when the central exertion is probably higher than the exertion in the entire body (total). If the difficulty is located in muscles and/or joints, a local rating may say more than an overall rating. The instructions above can then be modified so that the person is instructed to especially notice the exertion centrally or locally. When untrained, but healthy individuals work on a cycle ergometer, the exertion in the legs is often considerably higher than the central exertion. However, if the work is on a treadmill (walking, jogging, running), the central and local exertion track each other relatively well and it most often suffices to ask the person to rate their overall degree of exertion.

Borg CR10 scale®

In contrast to the RPE scale, which is specially designed for ratings of exertion, the CR10 scale is a general scale. The CR10 scale can be used in the majority of areas where it is of interest to make use of the individual's subjective perceptions. This can include ratings of aches and pain both locally in the legs as well as centrally, such as chest pain or breathlessness (dyspnoea). In healthcare, VAS (Visual Analogue Scale) is often used. Here, the CR10 scale is an alternative that has proven to be very reliable (43).

0	Nothing at all	
0.3		
0.5	Extremely weak	Just noticeable
0.7		
1	Very weak	
1.5		
2	Weak	Light
2.5		
3	Moderate	
4		
5	Strong	Heavy
6		
7	Very strong	
8		
9		
10	**Extremely strong**	**"Maximal"**
11		
↓		
•	Absolute maximum	Highest possible

Gunnar Borg CR10 scale

Figure 6. Borg CR10 scale®.

Correct instructions are also necessary in the use of the CR10 scale.

> **Give the person the scale to look at.** With the help of this scale, you should say how strongly you feel the aches (the pain or any other current sensation). "Nothing at all" corresponds to 0 and means that you do not feel any aches at all (pain, etc.). "Extremely strong" (maximal) corresponds to a 10. For most people, this is the greatest pain (ache, etc.) they have ever experienced. A pain that is even stronger than what you have ever experienced before is conceivable, which is why the absolute maximum value (the highest possible) is a bit higher. If you feel that your experience is stronger than "Extremely strong" – that is stronger than you have ever expe-

> rienced before – you can respond with a number somewhat higher than 10, such as 11.3 or 12.5 or higher. "Extremely weak", which lies at 0.5 on the scale is something barely noticeable, in other words, the feeling is right on the edge of what is possible to feel. You use the scale in such a manner that you start by looking at the verbal expressions, then choose a number. If your perception (ache or the like) corresponds to "Very weak", you give a 1. If it is "Moderate", you give it a 3 and so on. You can use any numbers on the scale whatsoever, including half values, such as 1.5 or decimals such as 0.8 or 8.3. It is very important that you say what you feel and not what you think you should say. Rate as honestly and frankly as possible and try to not underestimate or overestimate it. Remember to base your rating on the verbal expressions in front of each rating. Then say a number.

Control of intensity

Both the RPE and the CR10 scales can be used to control physical activity carried out for rehabilitative purposes. After the patient has gotten to know the scale(s) and received proper instructions on how to rate exertion (RPE scale) or aches, pain or the like (CR10 scale), it is possible to prescribe appropriate intensity levels that can then be used in rehabilitation. The intensity levels must of course be based on the person's situation, illness and conditions. In the respective chapters, recommended intensity levels are given, which is why we refer to these with regard to suitable levels for rehabilitation or preventative exercise activity.

If perception ratings are to control the intensity in rehabilitation, it is important to subject the patient to the activity in question under controlled circumstances. When the patient rates his/her exertion (pain or the factor in question) at the same time that pulse, blood pressure and other current physiological parameters are registered, it is possible to determine if the person tends to over or underestimate his/her perceived exertion/pain. An appropriate level of intensity can thereby be "calibrated" for the unique conditions of each individual so that the risk of over-exertion in association with rehabilitation is minimised.

Lastly, a word of warning. It has been shown that people perceive cycling, walking, jogging, running and so forth as less strenuous outdoors than indoors (in a laboratory). This means that the prescribed level of exertion must be adjusted downwards. If the person rates his or her exertion as a "15" (Hard) on the RPE scale in the lab and this is deemed to be an adequate level, the recommendation should be that the person not work harder than to a "13" (Somewhat hard). In fact, research has shown that the difference in perceived exertion is approximately two scale steps when the same type of exertion is done indoors and outdoors, respectively (37).

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