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Effort: Perception of

Perception of effort, also known as perceived exertion or sense of effort, refers to the conscious sensation of how hard, heavy, and strenuous a physical task is. This perception depends mainly on feelings of effort in the active limbs, and the sensation of heavy breathing (a type of dyspnea). Several authors think that somatic sensations such as muscle pain, thermal discomfort, and chest pain also contribute to perceived exertion. However, it has been demonstrated that people can differentiate perception of effort from these somatic sensations experienced during exercise (e.g., muscle pain). This entry describes the history, measurement methods, physiological and psychosocial determinants, neurophysiology, effort and other perceptions, and relevance and practical applications of perception of effort.

History and Measurement Methods

The sense of effort, including perception of force and weight, has been studied by psychologists and physiologists since the mid-to-late 19th century. However, the construct of perceived exertion was introduced in the early 1960s by Gunnar Borg, a Swedish psychophysicist with an interest in exercise. Borg also developed the two most common instruments used to measure perception of effort: the rating of perceived exertion (RPE) scale and the category-ratio (CR-10) scale. Both scales are based on the principle that most people share meanings of “no exertion” and “maximal exertion” based on similar experiences with physical activity, and careful selection of verbal expressions of effort to obtain category scales with interval or ratio properties.

The RPE scale measures the intensity of perceived exertion on a 15-point category scale representing equal intervals and ranging from 6 (“no exertion at all”) to 20 (“maximal exertion”). Seven of the 13 intermediate points are anchored to verbal expressions of effort such as “very light,” “somewhat hard,” and “heavy.” The CR-10 scale can be used to rate not only perception of effort, but also the intensity of other sensations such as pain. This scale ranges from 0 (no perception) to 10 (the strongest perception ever experienced) with various verbal anchors (e.g., “weak” and “moderate”). Subjects can give ratings higher than 10 (e.g., 13) if they perceive an intensity stronger than the one they have ever experienced. With proper familiarization and standardized instructions, both instruments have good reliability and validity. The latter has been demonstrated by significant correlations between RPE and objective measures of physiological strain (e.g., heart rate and blood lactate concentration) during exercise with incremental workloads.

Although the RPE scale and the CR-10 scale are the most widely used, other instruments have been developed to rate perception of effort. These methods include visual analog scales and pictorial scales portraying people exercising at different intensity levels. Classical psychophysical methods such as magnitude estimation, weight discrimination, and force-matching have also been used to quantify perceived exertion.

Physiological and Psychosocial Determinants

The workload at which somebody is exercising (e.g., running speed, resistance on the stationary bike, or amount of weight lifted) is an important factor determining perception of effort. Indeed, perceived exertion increases as workload increases. However, across individuals, there is a poor relationship between absolute workload and perception of effort. This is because perceived exertion accurately reflects relative exercise intensity, which depends on two factors: absolute workload and individual exercise capacity (i.e., physical fitness). For example, the same running speed of 12 kilometers per hour (km/h) can be perceived as “very hard” by an unfit middle-age man or as “very light” by an endurance athlete. However, both subjects would perceive a similar effort when running at 80% of their maximum endurance running capacity. Because physical fitness is affected primarily by physical training and health status, these two factors are important determinants of perceived exertion. Another important determinant of perceived exertion is the duration of the exercise bout. Perception of effort is known to increase significantly over time during prolonged exercise at a fixed workload. This phenomenon is an essential feature of fatigue during physical tasks. Nutritional (e.g., caffeine and muscle glycogen) and environmental factors (e.g., altitude and ambient temperature) are among many other physiological factors affecting perceived exertion.

Like other subjective feelings, perception of effort or its rating can be affected by psychological factors. These include personality, mood, somatic perception, locus of control, and self-efficacy. The presence and gender of another person during exercise testing can also influence RPE, but the effects of other social factors are poorly understood at present. Both psychological and social factors seem to affect perception of effort at low-to-moderate exercise intensities rather than during high-intensity exercise.

Neurophysiology

The neurophysiology of perceived exertion has not been extensively investigated, and its exact mechanisms are still being debated. One point of view is that perception of effort results from the complex integration of different afferent sensory inputs to the brain including those underlying proprioception, pain, and thermal discomfort. This proposal is supported by the significant correlations between RPE and several indicators of physiological strain measured during exercise (e.g., heart rate and blood lactate concentration). However, these high correlations may not be indicative of a cause-and-effect relationship. Indeed, because RPE increases as workload increases, any physiological variable that increases with workload could be related to RPE. Importantly, perception of effort is not affected by interventions (e.g., epidural anesthesia and lung transplantation) that block afferent feedback from receptors sensing the physiological conditions of skeletal muscles and internal organs.

An alternative explanation is that perception of effort reflects the magnitude of the central motor commands sent from the brain to the active muscles, including the respiratory muscles. This is achieved by forwarding neural signals, termed *corollary discharges,* from motor to sensory areas of the cerebral cortex. This view is supported by several experimental studies in which peripheral neuromuscular function is reduced using, for example, partial curarization or muscle fatigue. In these experimental conditions, higher perception of effort is thought to reflect the increased central neural drive necessary to exercise at the same workload with weaker muscles.

Experimental studies using hypnotic suggestion, dissociative cognitive strategies, imagery, psychoactive drugs, and mental fatigue suggest that cognitive factors are also important for perception of effort. Some of these experimental manipulations have also been used to locate the cortical areas associated with RPE using positron emission tomography. These areas include the anterior cingulate cortex, insular cortex, thalamus, and supplementary motor area.

Effort and Other Perceptions

Perception of effort interacts with other sensory information (e.g., proprioception and optical information) to produce other perceptions. For example, experimentally induced muscle weakness influences the perception of static limb position because more effort is required to hold the limb against gravity. When the limb is not held against gravity (no effort required), muscle weakness does not influence judgments of static limb position.

Experimental manipulations of effort also affect perception of distance. For example, wearing a heavy backpack significantly increases subjective judgments of distance to various targets. Interestingly, in this and other experiments, higher effort was anticipated. Therefore, effort does not need to be exerted to affect perception of distance.

Relevance and Practical Applications

Perceived exertion is a common phenomenon in daily life (e.g., climbing a flight of stairs or lifting a heavy object). Therefore, this perception plays an important role in regulating our physical activity behaviors. These behaviors range from choosing the pace during endurance competitions to adopting a sedentary lifestyle. It has also been proposed that primary disturbances in the sense of effort may underlie some of the symptoms characteristic of chronic fatigue syndrome and schizophrenia.

From an applied perspective, RPE is widely used as an adjunct to physiological and clinical measures (e.g., electrocardiogram) during maximal exercise tests. It can also be used to predict exercise capacity from responses to submaximal exercise tests. Because it accurately reflects relative exercise intensity, perception of effort is useful to prescribe and monitor exercise intensity in individuals participating in endurance and team sports, cardiac rehabilitation programs, and fitness training. The RPE scale has also been applied to evaluate work demands in a variety of occupations involving significant physical effort.

Samuele Marcora

See also Brain Imaging; Corollary Discharge; Kinesthesia; Pain: Physiological Mechanisms; Proprioception; Psychophysical Approach; Scaling of Sensory Magnitude; Temperature Perception

Further Readings

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