

# Training-induced adaptive plasticity in human somatosensory reflex pathways

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## ABSTRACT

This paper reviews evidence supporting adaptive plasticity in muscle and cutaneous afferent reflex pathways induced by training and rehabilitative interventions. The perspective is advanced that the behavioral and functional relevance of any [intervention](#) and the reflex pathway under study should be considered when evaluating both adaptation and transfer. A cornerstone of this concept can be found in acute task-dependent reflex modulation. Because the nervous system allows the expression of a given reflex according to the motor task, an attempt to evaluate the training adaptation should also be evoked under the same conditions as training bearing in mind the functional role of the pathway under study. **Within this framework, considerable evidence supports extensive adaptive plasticity in human muscle afferent pathways in the form of operant conditioning, strength training, skill training, and locomotor training or retraining. Directly comparable evidence for chronic adaptation in cutaneous reflex pathways is lacking. However, activity-dependent plasticity in cutaneous pathways is documented** particularly in approaches to neurological rehabilitation. Overall, the adaptive range for human muscle afferent reflexes appears bidirectional (that is, increased or reduced amplitudes) and on the order of 25–50%. The adaptive range for cutaneous pathways is currently uncertain.

rehabilitation; neural function; movement; neuroscience; electrical stimulation

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A simple reflex is probably a purely abstract conception, because all parts of the nervous system are connected together and no part of it is probably ever capable of reaction without affecting and being affected by various other parts, and it is a system certainly never absolutely at rest. But the simple reflex is a convenient, if not a probable, fiction. Reflexes are of various degrees of complexity, and it is helpful in analyzing complex reflexes to separate from them reflex components which we may consider apart and therefore treat as though they were simple reflexes. —Sir Charles S. Sherrington, "The integrative action of the nervous system," 1906

ACTIVITY-DEPENDENT PLASTICITY of neural function is a topic of increasing interest in applied physiology and rehabilitation. In both rehabilitation and exercise training the objective is often to cause a long-standing change in function (e.g., movement pattern) by applying some intervention (e.g., specialized exercise or therapy). To have a principled basis for an intervention requires an understanding of the extent to which the nervous system can accommodate to increased or decreased use before a long-standing change in control and function occurs. This is not a trivial issue because function in the nervous system is dynamically regulated. That is, adaptive plasticity is commonplace either in the form of rapid and short-term change (i.e., "acute adjustments") or as longer-standing and persistent change (i.e., "chronic plasticity"). The use of this terminology borrows from the concepts described by Enoka (31) to differentiate temporary adjustments from persistent change.

In this review the focus is on adaptive plasticity in human reflex pathways induced by physical activity. The scope is delimited to alterations in reflex function in muscle and cutaneous afferent pathways. A central issue is the conceptual framework in which the induction of adaptive plasticity can be best understood. This relates to considering training and reflexes in a certain context. [Table 1](#) illustrates the general concept where training can be considered as direct or indirect. Direct training refers to training aimed specifically at modifying the reflex under study. That is, the reflex itself is "targeted." Operant conditioning is the best example of this. The indirect context refers to training in which modification of the reflex is not itself the objective of training but rather occurs "en passant" (in passing; to borrow from chess) as part of the broader context of the training. Strength training or locomotor retraining can be considered the simplest and most complex forms of training in this context. The last thing that is contained in [Table 1](#) relates to a rough approximation of how strongly a given reflex pathway is related to the behavioral and functional relevance of the training context.