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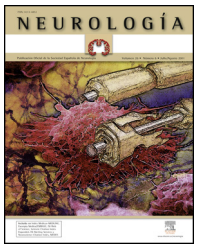

REVIEW ARTICLE

Theories and control models and motor learning: Clinical applications in neurorehabilitation☆

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Abstract
Introduction: In recent decades there has been a special interest in theories that could explain the regulation of motor control, and their applications. These theories are often based on models of brain function, philosophically reflecting different criteria on how movement is controlled by the brain, each being emphasised in different neural components of the movement. The concept of motor learning, regarded as the set of internal processes associated with practice and experience that produce relatively permanent changes in the ability to produce motor activities through a specific skill, is also relevant in the context of neuroscience. Thus, both motor control and learning are seen as key fields of study for health professionals in the field of neurorehabilitation.
Development: The major theories of motor control are described, which include, motor programming theory, systems theory, the theory of dynamic action, and the theory of parallel distributed processing, as well as the factors that influence motor learning and its applications in neurorehabilitation.
Conclusions: At present there is no consensus on which theory or model defines the regulations to explain motor control. Theories of motor learning should be the basis for motor rehabilitation. The new research should apply the knowledge generated in the fields of control and motor learning in neurorehabilitation.

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PALABRAS CLAVE
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Teorías y modelos de control y aprendizaje motor. Aplicaciones clínicas en neurorrehabilitación

Resumen
Introducción: En las últimas décadas ha existido un especial interés por las teorías que podrían explicar el gobierno del control motor y sus aplicaciones. Estas teorías suelen basarse en modelos de función cerebral, reflejando criterios filosóficamente diferentes sobre la forma en la que el movimiento es controlado por el cerebro, enfatizando cada una de ellas en los distintos componentes neurales del movimiento. Asimismo, en el contexto de las neurociencias, toma relevancia el concepto de aprendizaje motor, considerado como el conjunto de procesos internos asociados a la práctica, y la experiencia, que producen cambios relativamente permanentes en la capacidad de producir actividades motoras, a través de una habilidad específica. Por lo que ambos, control y aprendizaje motor, se posicionan como campos de estudio fundamentales para los profesionales sanitarios en el campo de la neurorrehabilitación.
Desarrollo: Se describen las principales teorías de control motor como la teoría de la programación motora, la teoría de sistemas, la teoría de la acción dinámica o la teoría del procesamiento de distribución en paralelo, así como los factores que influyen en el aprendizaje motor y sus aplicaciones en neurorrehabilitación.
Conclusiones: En la actualidad no existe un consenso sobre qué teoría o modelo es definitorio en dar explicación al gobierno del control motor. Las teorías sobre el aprendizaje motor deben ser la base para la rehabilitación motora. Las nuevas líneas de investigación deben aplicar los conocimientos generados en los campos del control y aprendizaje motor en neurorrehabilitación.

Introduction

Studying the cause and nature of movement is essential in medical practice. Recently, doctors have shown particular interest in new theories about motor control (MC) and their applications. However, due to new research in the field of neuroscience, the scientific community lacks a single theory regarding MC and distance is growing between the theories and the therapeutic interventions used for alterations in MC.[1]

The specific methods that are typically used in neurorehabilitation therefore rest on basic suppositions about the cause and nature of movement, meaning that MC theory actually stems from the theoretical basis underlying therapeutic practices.[2]

In general terms, the purpose of neurorehabilitation is to cement patients' existing skills, retrieve any lost skills, and promote learning of new abilities. A variety of factors may have a significant effect on neurorehabilitation and influence motor learning processes. These factors include verbal instructions, characteristics and variability of training sessions, the individual's active participation and motivation, positive and negative learning transfer, posture control, memory, and feedback. All of these factors are clinically applicable and they provide the basis for emerging or established lines of research having to do with retraining sensorimotor function in neurological patients.

The purpose of this study is to present a critical analysis of existing theories and models of MC and motor learning, and also study their potential clinical applications in the field of neurorehabilitation, referring fundamentally to regaining postural control and balance, locomotion, reach, grasp, and manipulation. Lastly, we describe the true possibilities for new technologies applicable to neurological disease.

Background

Theories on motor control

The different theories on MC reflect existing ideas of how movement is controlled by the brain. Each different theory emphasises the different neural components of movement.[1] The specific methods used in neurorehabilitation are therefore based on general suppositions about the cause and nature of movement, meaning that MC theory actually stems from the theoretical basis underlying therapeutic practices,[2] which in turn corroborate or refute these theories.[3] The main limitations and clinical implications of different MC theories are shown in Table 1.

Reflex theory

In 1906, the neurophysiologist Sir Charles Sherrington established the basis for the reflex theory of motor control,[4] according to which reflexes were the building blocks of complex behaviour intended to achieve a common objective.[5] He described this behaviour in terms of compound reflexes and their combined or chained action.[6–14] A stimulus provokes a response, which is transformed into the stimulus of the next response.