H-reflex as an Outcome Measure in Individuals with Spinal Cord Injury - A Systematic Review

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Abstract: Aim: The aim of the study was to explore the available evidence and literature regarding the use of H-reflex in patients with Spinal Cord Injury. Materials and methods: A literature search was conducted in December 2019 and compilation of literature that is published from 2009 to 2019 was included in the study using common search engine i.e. Pubmed. The Inclusion criteria were 1) Prospective or retrospective cohort studies, 2) studies that included only participants with spinal cord injury 3) studies that included H-reflex in any form were investigated 4) Full text articles from peer-reviewed journals were included. Studies based in the form of Experimental, Quasi experimental and observational studies were included. Exclusion criteria were 1) Studies in any other language than English were excluded 2) Studies which had been carried out on animals were excluded. Result: Thirteen articles were included and analysed in detail in this review on the basis of the selection criteria. It showed that the H-reflex can be a useful tool in evaluating the prognosis, as it assess the excitability below the level of injury. Conclusion: H-reflex is useful in diagnostic and prognostic clinical value that could be used to monitor recovery of motor function after SCI.

Keywords: H-reflex and Spinal Cord injury, Hoffman reflex, Electrophysiological tests and SCI, Soleus H-reflex

1. Introduction

Spinal Cord Injury (SCI) is truthfully a devastating injury with profound consequences to the individual. It is recognized musculoskeletal condition that is major and is present with severe burden.[1]

Discontinuity in the spinal cord is outcome of spinal cord injury that causes impairments that are functional as lower limb weakness with involvement of sensory system[2], dysfunction of bladder, bowel, respiratory and sexual which is based on the site and level of injury according to which symptoms may be different. There is dependence of recovery of function on the type of injury weather it is incomplete or complete on ASIA scale for impairment. There is loss of sensory as well as motor functions in case of complete type of injury whereas sensory and motor function are preserved in case of incomplete injury below the level of injury so it is predicted that recovery is more in cases with incomplete type of injury when compared with complete type of injury.[3]

In a previous review, it has been stated that various electrophysiological tests are used in SCI viz. Electromyography (44%), Motor Evoked Potential (33%), Somatosensory Evoked Potential (33%), H-reflex (20%), and Nerve Conduction Studies (9%).[4]

H-reflex is an electrically stimulated reflex that is revealed in EMGs and it is considered as a significant measurement method for estimating modulation of monosynaptic reflex activity in the spinal cord. It is elicited by submaximal of the tibial nerve and recorded from the calf muscle in lower limb.[5] The pathway of the H-reflex is composed of group Ia sensory fibres which form a synapse with α-motoneurons and their axons [6] There are different types and patterns of H-reflex abnormalities, which depends upon the severity, level, and duration of the lesion which has been reported in individuals with SCI.[5] Various neurophysiological reflex studies have been used to assess spinal sensorimotor excitability during different movement tasks. [7] Extensive research have proven the importance of H-reflex in various conditions like Radiculopathy, GBS and other neurological disorders. The aim of this review is to explore the available evidence and literature regarding the use of H-reflex in patients with Spinal Cord Injury.

2. Materials and Methods

2.1 Search Strategy

A literature search was conducted in December 2019 and compilation of literature that is published from 2009 to 2019 was included in the study using common search engine i.e. Pubmed. The keywords used for literature search were H-reflex and Spinal Cord injury, Hoffman reflex, Electrophysiological tests and SCI and Soleus H-reflex.

2.2 Study selection and data extraction

The Inclusion criteria were:
1) Prospective or retrospective cohort studies
2) Studies that included only participants with spinal cord injury
3) Studies that included H-reflex in any form were investigated.
4) Full text articles from peer-reviewed journals were included. Studies based in the form of Experimental, Quasi experimental and observational studies were included.

Exclusion criteria were:
1) Studies in any other language than English were excluded.
2) Studies which had been carried out on animals were excluded.
3. Result

<table>
<thead>
<tr>
<th>Name of the journal and year</th>
<th>Number of subjects</th>
<th>Intervention given</th>
<th>Outcome measure</th>
<th>Author and conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Neurophysiology 2013</td>
<td>N=9 chronic SCI</td>
<td>Prolonged Wide-pulse NMES was given in two patterns i.e. constant-frequency and burst frequency.</td>
<td>Soleus H-reflex and M wave was recorded during both the patterns.</td>
<td>J.M. Clair-Auger found that large H-reflex was recorded in both the patterns of NMES but burst of 100 Hz stimulation restored H-reflex to their initial amplitudes, effectively reversing the effects of post activation depression.[8]</td>
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<tr>
<td>American Physiological Society 2014</td>
<td>N=16 chronic SCI</td>
<td>BWS-assisted locomotor training with robotic exoskeleton system 45 training session, 5 days/week, 1hr/day</td>
<td>Soleus H-reflexes were evoked during seated and stepping at 1.0, 0.33, 0.20, 0.14, 0.11 Hz were normalized.</td>
<td>Maria Knikou concluded that locomotor training changed the amplitude of locomotor EMG excitability, promoted intralimb and interlimb coordination also improves premotoneuronal control after SCI in humans at rest and during walking. Synergistic group I afferents may contribute to the soleus H-reflex depression during the swing phase.[9]</td>
</tr>
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<td>The Neuroscientist 2014</td>
<td>20 control H-reflexes are elicited as in the baseline sessions and then 3 blocks of 75 conditioned H-reflexes (i.e., 225 total) were elicited</td>
<td>Soleus H-reflex is elicited while the subject maintains a natural standing posture</td>
<td>Aiko Thompson concluded that the Operant conditioning protocols, which can target plasticity to specific reflex pathways, might enhance functional recovery. SCI indicate that appropriate operant conditioning of the soleus H-reflex can improve walking.[10]</td>
<td></td>
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<tr>
<td>Neurorehabilitation 2016</td>
<td>N=13 normal subjects 10 iSCI</td>
<td>Intervention 1: cycling for 10 minutes on static ergometer</td>
<td>Reflex Modulation was assessed immediately before and after the session by H reflex</td>
<td>Stefano Piazza concluded that cycling with electrical stimulation promotes spinal processing of sensorimotor function in iSCI more than cycling alone. After ES-cycling a significant increase in H-reflex excitability was observed in both the groups.[11]</td>
</tr>
<tr>
<td>Medical and Biological Engineering and computing 2018</td>
<td>N= 6 iSCI, 5 cSCI 13 Healthy individuals</td>
<td>Participants were instructed to cycle for 42rpm for 10 minutes at a resistance that is comfortable. cSCI group was assisted by electrical motor</td>
<td>Plantar cutaneous conditioned H reflex modulation patterns was observed during cycling and walking.</td>
<td>Stefano Piazza found that no modulation of soleus H reflex with plantar cutaneous stimuli was observed after iSCI or cSCI when compared with healthy population. Afferent stimulation could be adopted with diagnostic and prognostic purpose.[7]</td>
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</table>
The purpose of the review was to determine the use of the H-reflex as an outcome measure in individuals following SCI. Advantages of electrophysiological studies are: 1) it facilitates understanding of the underlying pathophysiological mechanisms of SCI and how the neurological recovery is improved by therapeutic interventions. 2) they are more sensitive, reliable and provides the quantitative data which is valuable for the diagnosis.

Various neurophysiological reflex studies have been used to evaluate spinal sensorimotor excitability during different movement tasks. Neurophysiological conditioning techniques using the soleus H-reflex as the test reflex marker of spinal excitability have also been used to improve our understanding of sensorimotor control in healthy subjects and individuals with SCI. [7]
The possible underlying mechanism could be a deficit in the modulation of proprioceptive Ia afferent activation of alpha motoneurons in people with independent or assistive ambulation after SCI, diminished or absent inhibition of cutaneomuscular conditioned soleus H-reflex activity

Fung and Barbeau used a similar testing paradigm to quantify the effect of a cutaneomuscular conditioning stimulus on the soleus H-reflex during walking, showing that reflex inhibition was diminished or absent after moderate to severe SCI associated with the spasticity syndrome.[7]

Piazzo et al also reported whether a longer duration and repeated ES cycling intervention could lead to improvement in neuromuscular function after SCI, as observed using other clinical conditioning protocols using the H-reflex as the test measure. Change in cutaneomuscular-conditioned H-reflex excitability following ES cycling may have a diagnostic and prognostic clinical value that could be used to monitor recovery of motor function after SCI and could be applied to identify responders to new neurorehabilitation therapeutic approaches.[11]

Kim et al used H-reflex modulation across the muscle action to see the spinal reflex excitability in patients with SCI and found the increase spinal reflex excitability after SCI when compared to normal individuals during lengthening action. Further he added that the presynaptic inhibition of Ia afferent terminals as a mechanism for reduction in length of Hmax/ Mmax in normal individuals. As, presynaptic inhibition of Ia afferents is thought to be diminished following SCI.[15]

Maria Knikou et al also reported that spinal inhibition is reduced following SCI and it can be improved with locomotor training. H-reflex was elicited before and after the locomotor training so as to observe the changes of the soleus H-reflex long latency depression. In this study also H-reflex was used to evaluate the spinal excitability and find out the possible mechanism for the recovery in the individuals with SCI.[9] Several studies revealed peripheral NCS and intramuscular EMG detects and characterize concomitant traumatic damage to the peripheral nervous system if present, such as radiculopathy, nerve plexus damage or peripheral neuropathy, and help distinguish them from spinal cord damage. SSEPs, CHEPs, and MEPs are used for testing conduction in long spinal tracts conveying afferent somatosensory and efferent motor information across the lesion site in individuals with more severe injuries. However, such conductivity assessments of spinal tracts as SSEPs, CHEPs, MEPs are limited in terms of evaluating safety as evoked potential across the lesion are likely not recordable and thus, no baseline recording may be obtained from which to measure a detrimental change.[20] Furthermore, H-reflex and F-wave recordings not only prove integrity of the proximal segment of the peripheral nerve but also assess the excitability of LMN below the lesion. The future studies can be done particularly on the use of H-reflex in the therapeutic intervention so that to understand how the H-reflex modulation helps in recovering the motor functions in patients with SCI.

5. Conclusion

H-reflex is useful in diagnostic and prognostic clinical value that could be used to monitor recovery of motor function after SCI.

References

[12] Knikou M, Angeli CA, Ferreira CK, Harkema SJ. Soleus H-reflex modulation during body weight support treadmill walking in spinal cord intact and


