CYCLING TRAINING AND FUNCTIONAL ELECTRICAL STIMULATION FOR POST-STROKE PATIENTS

INVESTIMENTO DE EXERCÍCIO E ELETRICIDADE FUNÇÕAL PARA PACIENTES PÓS ACIDENTE VASCULAR CÉREBRAL

ENTRENAMIENTO DE CICLISMO Y ESTIMULACIÓN ELÉCTRICA FUNCIONAL PARA PACIENTES POST-ATACO VASCULAR CEREBRAL

ABSTRACT

Introdução: Stroke is one of the leading causes of morbidity and mortality in adults worldwide. The prevalence of stroke in developing countries such as South Africa and Iran is growing, especially in an increasingly younger population. In Iran, the annual stroke incidence ranges from 23 to 103 per 100,000 inhabitants, with the rate being higher in those aged 15-45 years. Problematically, almost 50% of stroke patients face difficulties in performing activities of daily living, hence the importance of functional rehabilitation. These factors necessitate cost-effective solutions in developing countries, where there is insufficient research focused on practical solutions for treatment/rehabilitation. Objective: We hypothesize that while progressive cycling training would activate cortical regions and that cycling speed feedback could lead to additional cortical activations and resultant improvements in cycling performance, combined cycling training and functional electrical stimulation would result in superior improvements in cycling performance, aerobic capacity, and functional performance in post-stroke patients. Conclusions: Ultimately, we expect this hypothesis to provide a useful framework for facilitating combined cycling and functional electrical stimulation rehabilitation research in post-stroke patient populations. Level of Evidence V; Expert opinion.

Keywords: Aerobic exercise; Stroke; Neurehabilitation.

RESUMO

Introdução: Acidente vascular Cerebral é uma das principais causas de morbidade e mortalidade em adultos ao redor do mundo. A prevalência de AVC em países em desenvolvimento, como África do Sul e Irã, tem aumentado principalmente na população cada vez mais jovem. No Irã, a incidência anual de AVC varia de 23 a 103 em cada 100.000 habitantes, com aumento da taxa entre 15-45 anos. Problematicamente, quase 50% dos pacientes que sofreram AVC têm dificuldade de praticar atividades cotidianas, por isso a importância da reabilitação funcional. Estes fatores exigem a necessidade de soluções econômicas nos países em desenvolvimento, onde há pesquisas insuficientes que focam em soluções práticas para o tratamento/reabilitação. Objetivo: nossa hipótese é que o treinamento ciclístico progressivo pode ativar regiões corticais e a resposta da velocidade do ciclismo levaria a ativação corticais adicionais e melhoras resultantes no desempenho do ciclismo, treinamento combinado de ciclismo e estimulação elétrica funcional resultariam em melhorias superiores no desempenho do ciclismo, na capacidade aeróbica e no desempenho funcional em pacientes pós-AVC. Conclusão: Por fim, nós esperamos que essa hipótese providencie uma estrutura útil para facilitar a pesquisa em treinamento combinado de ciclismo e reabilitação em estimulação elétrica funcional em pacientes pós-AVC. Nível de Evidência V; Opinião do especialista.

Descritores: Exercício; Acidente vascular cerebral; Reabilitação neurológica.

RESUMEN

Introducción: El accidente cerebro-vascular es una de las principales causas de morbilidad y mortalidad en adultos en todo el mundo. La prevalencia de accidente cerebro-vascular en países en desarrollo, como Sudáfrica e Irán, está en aumento, especialmente en una población cada vez más joven. En Irán, la incidencia anual de ataque varía de 23 a 103 por 100.000 habitantes, y la tasa es más alta en personas de 15 a 45 años. El problema radica en que casi el 50% de los pacientes que sufrieron un accidente cerebro-vascular tienen dificultad para realizar actividades de la vida diaria. De ahí la importancia de la rehabilitación funcional. Estos factores requieren la necesidad de soluciones rentables en los países en desarrollo, donde no hay suficiente investigación que se centre en soluciones prácticas para el tratamiento/rehabilitación. Objetivos: Nuestra hipótesis es que, mientras el entrenamiento de ciclismo progresivo activaría las regiones corticales y que la retroalimentación de la velocidad de ciclismo podría conducir a activaciones corticales adicionales y mejoras resultantes en el rendimiento del ciclismo, el entrenamiento combinado de ciclismo y estimulación eléctrica funcional daría como resultado
INTRODUCTION

Stroke is a non-communicable disease of increasing importance since it was the second most common cause of mortality in 1990 and ranked third concerning mortality in developed countries in 1990.1 Stroke is also a significant cause of long-term disability and has potentially vast socioeconomic and emotional outcomes for communities and countries.

Stroke survivors are often at least partially dependent on other individuals and/or special equipment in performing activities of daily living (ADLs).2 This is because both their static and dynamic balance is usually heavily affected, and this increases the incidence of falls.3 In addition, lack of postural control has the greatest impact on a patient’s gait and independent performance of ADLs, and such disability arises from limitations in activities and reduced participation in daily life tasks.4 With hemiplegia contributing significantly to an inability to perform meaningful activities and participate fully in life following stroke,5 improving motor outcomes after stroke is essential and an optimal and rapid therapeutic intervention is required. To improve outcomes after stroke, intervention focuses on improving not only the impairment level, but also addressing activity limitations, such as walking and moving objects, and participation restrictions.6

Role of cycling in post-stroke rehabilitation

Previous studies have revealed that aerobic training (AT) improves aerobic capacity by an average of 2.27 mL·kg⁻¹·min⁻¹.7 Generally, post-stroke rehabilitative cycling is executed to increase aerobic capacity via continuous or interval training with a heart rate of 50% to 80% of maximum.7,8 Previous studies that have utilized cycling for the rehabilitation of post-stroke patients in different genders and ages, have generally utilized a flat duration of exercise training of not more than 30 minutes following three months of training.9,10

In addition to an increased aerobic capacity, other benefits such as gait endurance, gait speed, and quality of life have been observed following post-stroke rehabilitative cycling.11,12 These results are important in that walking restoration is known as the major aim of post-stroke lower-limb rehabilitation, and the speed of gait considered as a consistent deficit severity sign.13 In addition, trunk control is considered to be a significant requirement to control more compound limb activities,14 and as such, it is necessary to identify an available treatment which can improve trunk control in the early treatment phase. Considering this context, an excellent candidate seems to be cycling training.15

These benefits are due to the capability of the cycling motion, which can activate somatosensory receptors and create rising inputs to the central nervous system.16 Research in both stroke patients and healthy subjects have shown that proprioceptive inflow from movements of upper-limb can increase activation in the sensory and sensorimotor cortex (SMC), additional motor area (SMA), secondary sensory cortex and premotor cortex (PMC), with resulting enhancement in performance of motor.17

Role of electrical stimulation in post-stroke rehabilitation

Electrical stimulation, in the form of Functional Electrical Stimulation (FES), especially when combined with other established modes of rehabilitation, such as cycling, has the potential to improve motor outcomes post-stroke and as such, potentially lead to increased activity performance and participation.18 This is because, while FES has limited benefits of its own,19 FES can be utilized to enhance the effect of cycling in post-stroke rehabilitation.

Problematically, while limited studies have investigated the effects of FES on cycling, there is a clear variance among previous studies about the combined cycling and FES exercise design. In this regard, it is important to note that there is a need to propose a combined cycling and FES exercise protocol than can easily be performed in an in-patient or out-patient setting.13 To ensure success, the exercise protocol should not only replicate those successful cycling studies, but also provide novel and effective prescriptions for combining FES.14

CONCLUSIONS

To this end, this paper suggests a three times weekly progressive pattern of passive cycling with FES for five weeks, with an initial duration of 10 minutes (including two minutes warm-up and two minutes cool-down of passive cycling) in first week for neuromuscular adaptation. This initial pattern should be followed for three sessions in first week to allow for neuromuscular adaptations to take place. Following which, the second week, will begin with 15 minutes (including two minutes warm-up and two minutes cool-down of passive cycling) of cycling, and duration should be increased each session by 3.3 minutes (i.e. 10 minutes will be added each week) until a total duration of 45 minutes is achieved in the fifth week. Patients should not voluntarily contribute to the pedalings instead they should concentrate on the exercise. Throughout passive cycling, the legs of patient are required to be moved only by the ergometer’s motor that assures a steady speed of 20 revolutions per minute (rpm) during the training session. The exercise intensity for each session should be set and monitored as a percentage of the individual heart rate reserve.20

As a concurrent treatment to the cycling, it is recommended that patients utilize a current-controlled 8-channel stimulator and surface electrodes in a bipolar configuration on both legs’ quadriceps, gluteus maximum, hamstrings, and tibialis anterior. Rectangular biphasic pulses with pulse width of 100-400 μs (should be based on personal acceptable tolerance), stimulation frequency of 20-40 Hz (should be based on personal acceptable tolerance), and the amplitude of 20 to 100 mA (should based on personal acceptable tolerance) should be utilized. In addition, numerous parameters concerning power and temporal sequence of the impulses should be adjusted individually for each channel. In addition to personal tolerance, the intensity of stimulus for each muscle should be set at a tolerated value that creates a visibly good muscle reduction.21 The timing of the stimulation should be synchronized to the cycling...
movement based on physiological stereotype activation patterns.\textsuperscript{22} To encourage a comparable mental set, patients should undergo an initiation sessions in an attempt to familiarize to sensations and to what is considered a visibly good muscle.\textsuperscript{23}

The most important differences between this suggested hypothesis with previous studies is related to progressive pattern of cycling, as most of the previous studies, used a fixed duration of cycling and as such, made the therapeutic process longer. Based on this hypothesis, concurrent cycling training and FES would result in superior improvements in cycling performance, aerobic capacity, and functional performance in post-stroke patients as a result of an increased activation of cortical regions.

In this regard, this method may prove particularly useful for those patients suffering a traumatic brain injury or first-time stroke that results in hemiparesis with an acute event interval (<6 months). However, these patients must display adequate cognition and be able to carry out active standard cycling treatment (i.e. able to sit up to 30 minutes, low spasticity in the lower limb muscles (modified Ashworth score <2) and display joint mobility ranges which would not prevent pedaling).

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