Aquatic Neuroscience Research and it´s Clinical Applications

Presenters:
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Target audience: All healthcare professionals, interested in Aquatic Therapy with patients with musculoskeletal, orthopaedic or neurological conditions.

Summary: This webinar aims to provide information about of brain processes induced by immersion and the effects of processing other stimuli in the water. This will help to delineate the mechanisms of cerebral processing and will facilitate the development of better therapeutic interventions in water for neurological patients. Immersion induces a variety of physiological responses in different body systems, depending on the fluidmechanical effects, which are the foundation that supports aquatic therapy programmes in different pathologies. The objective of the webinar is to analyse and describe the effects that vertical immersion produces on the nervous system in healthy subjects. Different clinical proposals arise from the evidence to hypothesize changes in subjects with neuromusculoskeletal conditions (still not investigated).

Learning objectives:

1. To explain the various types of vertical water immersion described in the literature.
2. To describe the different body systems that are modified by exposure to the aquatic environment in healthy subjects.
3. To describe the different outcome measures of the brain changes that occur while subject is inside the water.
4. To analyse and describe the effects of these types of immersion on the nervous system in healthy subjects.
5. To propose clinical applications in neuromusculoskeletal conditions based on these brain changes.

Description:

The review of studies to date (Güeita et al., 2019) shows mainly positive effects on cerebral vascularization, cortical activity (somatosensory and motor), executive functions, production of neuroprotective factors and motor learning and neuroplasticity. In no case there are adverse effects.

-Brain vascularization
The effects of water immersion show that, added to or not to external stimuli, it produces an increase in the speed of cerebral blood flow depending on the depth. The increase in the speed of cerebral blood flow is produced by vertical immersion at rest or combined with exercise. Carter et al. (2014) measured flow velocities in the middle and posterior cerebral arteries while vertical immersion was performed without exercise, while Pugh et al. (2015) performed immersion with exercise. The findings of both works show that immersion had an impact on hemodynamic variables, with an increase mainly in the cerebral blood flow velocity in both arteries with respect to the out-of-water group, whether it was performed with exercise or at rest. Parfitt et al. (2017) further studied the influence of exercise intensity and depth of immersion, and found that immersion and exercise in water at low intensities (walking) resulted in the same brain blood flow rate as with moderate intensity exercise on land (running). However, the depth of immersion increased the heart rate, while the brain flow rate remained stable, with a stable exercise speed.

-Cortical activity
The effects of water immersion on cortical activity have been analysed in several studies (Sato et al., 2012, 2012b, 2013, 2014, 2015 and 2017). The results showed that immersion induces an increase in site-specific activity in sensory and motor areas, due to differences in demands on the various brain functions, and that the modulation of cortical excitability is dependent on the intensity of the added stimulus. Most studies combine vertical immersion in water with different stimuli, such as laminar flows, electrical stimuli and

TMS; however, the effects described on cortical activity were also referred by authors who only performed vertical immersion.

-Executive functions
The effects of water immersion on executive functions have been analysed in two studies (Schaefer et al., 2016; Sato et al., 2017), in which a decrease in errors in the recognition of a mental task (auditory vigilance) was described (Schaefer et al., 2016) and a decrease in sympathetic activity induced by vertical immersion, although, in this case, the changes did not influence the performance of the executive function (Sato et al., 2017).

-Neuroprotective effects
Only the study by Kojima et al. (2017) has directly analysed the effect of immersion on neurotrophin production, and found an increase in brain-derived neurotrophic factor with immersion in warm water at rest. The effects of therapeutic exercise are well known on the release of neuroprotective factors, on the synthesis of neurotransmitters or on neurogenesis, initially induced by an increase in cardiac output. Exercise is a common practice to promote health, as secondary prevention in adult and pediatric neurological populations, while minimizing secondary consequences (Quinn and Morgan, 2017). However, Kojima et al. (2017) found that the increase in brain-derived neurotrophic factor after resting immersion was induced by increased body temperature, as it exposed subjects to 20 minutes of immersion at 35 and 42 °C, enabling the release of neurotrophins, even when moderate exercise in water is not possible in the early stages of recovery.

-Learning and Neuroplasticity
Sato and his collaborators are studying the *induced cholinergic neural activity* during immersion, as initial step to hypothesize a *priming effect* of water immersion on neuronal plasticity and learning. They propose that cholinergic neural activity would increase after immersion to re-regulate the level of decreased excitation during immersion. What occurs during immersion, the authors believe, is a decrease in acetylcholine concentration, similar to what occurs during the REM sleep phase. Cholinergic neural activity decreases significantly during non-REM sleep and increases to a waking condition during REM sleep. Therefore, due to the relevant role that acetylcholine plays as a neuromodulator in the transmission of electrical impulses, modulating cortical excitation (arousal), motor learning and memory, along with the changes that occur in it during immersion, Sato's group has developed new work (in process of publication) to assess cholinergic neural activity while subjects are in the water.
In line with previous research by Sato and his team, Bressel et al. (2018) studied the effects of immersion on the speed and accuracy of motor learning (implicit memory). Their results showed that learning was faster and with fewer errors in the water, compared to the control groups on land. Verbal and auditory memories were increased (explicit memory) in this study and the previous study by Schaefer et al. (2015), and interestingly, grip strength was also increased in the water compared to the control groups, suggesting that there may still be unexplored benefits to this form of therapy in water.

Elaborating on the brain processes induced by vertical immersion and the effects of processing other stimuli in water will help to delineate the brain's processing mechanisms and facilitate the development of better therapeutic interventions in water for patients with neuromusculoskeletal conditions.

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