Pedagogical resources
AQUATIC ACTIVITIES

SARCOPENIA: STRENGTH TRAINING, AQUAGYM AND HIPPOCAMPAL HEALTH IN OLD AGE

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March 16, 2026

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Sarcopenia affects not only muscle function but also brain activity. Physical exercise, particularly aquagym combined with strength training and dual-task training, acts as a restorative link between muscle function and hippocampal health.

Introduction

Population ageing has been accompanied by an increase in the prevalence of chronic conditions that compromise the functional ability and independence of older people. Among these conditions, sarcopenia stands out as a geriatric syndrome characterised by the progressive loss of muscle mass, strength and function, associated with an increased risk of falls, functional disability, hospitalisations and mortality (Cruz-Jentof et al., 2019).

Although historically understood as a predominantly peripheral phenomenon, recent evidence suggests that sarcopenia is closely linked to alterations in the central nervous system, particularly in brain regions involved in motor control, cognition and behavioural adaptation. In this context, the hippocampus emerges as a central structure at the interface between muscle function and brain health in ageing.

The hippocampus is a structure within the limbic system that is essential for episodic memory, spatial memory, learning, emotional regulation and cognitive-motor integration (Erickson et al., 2011). Unlike many cortical regions, the hippocampus retains its capacity for plasticity throughout life, being particularly sensitive to environmental and behavioural stimuli, such as physical exercise.

With advancing age, a reduction in hippocampal volume, synaptic alterations and a decrease in neurogenesis are observed, phenomena associated with cognitive decline and an increased risk of mild cognitive impairment and dementia (Raz et al., 2005). Factors such as a sedentary lifestyle, chronic inflammation, insulin resistance and psychological stress accelerate this process, whilst also contributing to the progression of sarcopenia, suggesting shared pathophysiological mechanisms.

Sarcopenia is not limited to the structural loss of skeletal muscle. The reduction in muscle strength and power compromises mobility, restricts exploration of the environment and

reduces exposure to sensorimotor and cognitive stimuli. This process has a negative impact on the activation of neural circuits involved in motor control and learning, including those dependent on the hippocampus.

The relationship between sarcopenia and the hippocampus

The relationship between sarcopenia and the hippocampus suggests that the decline in muscle function and changes in brain health during ageing are interdependent processes. The reduced mobility and sensorimotor stimulation resulting from sarcopenia impair cognitive and learning functions that depend on the hippocampus (Table 1).

Table 1. The relationship between sarcopenia and the hippocampus.

Sarcopenia	Functional impact	Relationship with the hippocampus
↓ Muscle mass	↓ Mobility	↓ Sensory-motor stimulation
↓ Strength	↑ Fall risk	↓ Cognitive-motor integration
↓ Power	↓ Walking speed	↓ Motor learning
↓ Function	↓ Independence	↓ Hippocampal activation
Inactivity	↑ Inflammation	Hippocampal atrophy

Strength training and hippocampal health

Strength training has been widely recognised as a key strategy in the treatment and prevention of sarcopenia. In addition to its well-known effects on muscle strength, power and function, strength training has significant impacts on the brain.

Clinical trials demonstrate that resistance training improves executive function, attention and overall cognition in older adults (Liu-Ambrose et al., 2010; Northey et al., 2018). From a neurobiological perspective, strength training promotes an increase in growth factors and myokines, such as IGF-1, BDNF and irisin, which cross the blood-brain barrier and promote synaptic plasticity, neurogenesis and the preservation of hippocampal volume (Cassilhas et al., 2007; Erickson et al., 2019).

These mechanisms demonstrate that strength training acts as a brain-muscle intervention, capable of simultaneously modulating peripheral muscle function and central brain health.

Strength training and its effects on the hippocampus

Strength training has significant effects not only on muscle function but also on brain health, with a direct impact on the hippocampus. Through neurobiological adaptations, such as increased neurotrophic factors, this form of exercise contributes to hippocampal plasticity and the improvement of cognitive functions associated with memory and learning (Table 2).

Table 2. Strength training, muscular effects and hippocampal response.

Muscular effect	Neurobiological mechanism	Hippocampal response
↑ Strength	↑ IGF-1	↑ Synaptic plasticity
↑ Function	↑ BDNF	↑ Memory and learning
↑ Power	↑ Cerebral blood flow	Structural preservation
↑ Mobility	↓ Inflammation	Improved stress regulation

Aquagym as a strength training strategy

Despite the benefits of land-based strength training, many older adults with sarcopenia experience joint limitations, chronic pain, a fear of falling or low baseline fitness, which makes it difficult for them to adhere to traditional programmes. In this context, aquagym emerges as a particularly relevant form of exercise.

The aquatic environment offers unique physical properties, such as:

- **Buoyancy**, which reduces joint load.
- **Viscosity**, which provides adjustable multidirectional resistance.
- **Hydrostatic pressure**, which can promote comfort and venous return.

These characteristics allow resistance exercises to be performed with greater safety and lower impact, facilitating adherence and enabling sufficient training volumes and intensities to promote gains in muscle strength and function (Katsura et al., 2010).

Integrated benefits of aquagym

Aquagym is a form of exercise with integrated benefits, acting simultaneously on muscle function, balance and cognition in older adults (Table 3). The properties of the aquatic environment promote safety, adherence and sensorimotor stimulation, contributing to hippocampal health and the maintenance of functional autonomy.

Table 3. Relationship between the priority dimension and the benefit of the activity.

Dimension	Benefit
Muscular	Multi-directional endurance
Joint	↓ Impact and pain
Functional	Improved balance
Cognitive	Stimulation of spatial memory
Emotional	↑ Participation and well-being
Neural	Activation of the hippocampus

In addition to its muscular benefits, aquagym is a cognitively stimulating activity, as the instability of the water, the variable resistance and the need for constant postural adjustments increase the demands on attention, motor control and spatial orientation, processes directly linked to hippocampal function.

Recent studies show that aquatic exercise programmes are associated with improvements in cognitive function in older adults, including memory and attention (Terra de Oliveira et al., 2024; Kooncumchoo et al., 2025). When aquagym is structured to include cognitive challenges, through dual-task exercises, learning motor sequences and decision-making, stimulation of the hippocampus is enhanced, promoting metabolic, structural and functional effects in this brain region.

The integration of strength training, aquagym and cognitive challenges creates a context in which physical exercise acts as a mediator of a virtuous cycle in ageing. Increased muscle strength and function enhance mobility and interaction with the environment, which, in turn, stimulates the hippocampus and contributes to the maintenance of cognition and functional autonomy.

This integrated approach reinforces the idea that interventions targeting sarcopenia must go beyond muscle, incorporating strategies that simultaneously promote brain plasticity and cognitive reserve.

Examples of stimuli for the hippocampus

Aqua aerobics allows for the application of specific stimuli to the hippocampus by combining movements with demands on attention, memory and spatial orientation. Activities such as dual-tasking, learning motor sequences and decision-making in the aquatic environment promote hippocampal activation and cognitive plasticity (Table 4).

Table 4. Example of exercise and activated cognitive function.

Type of task	Practical example	Cognitive function
Double task	Marching + counting	Divided attention
Memory	A-B-C sequence	Working memory
Decision-making	Changing direction	Executive function
Spatial	Moving through zones	Spatial memory
Inhibition	Ignoring false stimulus	Inhibitory control

Sarcopenia affects not only muscle but also brain stimulation; physical exercise, particularly aquagym combined with strength training and double tasking, acts as a restorative link between muscle function and hippocampal health.

Aquagym ceases to be merely an aerobic activity and comes to function as a neuromuscular and neurocognitive tool, contributing to the gain and maintenance of functional strength, the stimulation of spatial memory and attention, the reduction of fear of falling, increased adherence and emotional engagement, and the indirect stimulation of the hippocampus through motor learning, sensory stimuli and dual tasking.

Example of integrated periodisation in a 4-week programme

Phases	Objective	Physical content	Load	Cognitive component	Hippocampal stimulation
Phase 1 **Week 1** **Adaptation, safety and confidence**	Familiarisation with the aquatic environment General neuromuscular activation Reduction of stiffness and pain	Stationary walking and light movements Ample upper limb (UL) movements against water resistance Hip and knee flexion/extension Optional use of light aquatic dumbbells	2 to 3 sets of 30 to 45 s 4 to 5 repetitions	**Mild** **Sustained attention:** Counting movements Responding to name Following simple commands (right/left)	Stress reduction (HPA axis) Increased cerebral blood flow Foundation for future plasticity

Phase 2 **Week 2** **Functional strength + dual-task training**	Increase muscular endurance Stimulate working memory and decision-making Increase motor variability	Multi-directional walking Water jumps (low amplitude) Unilateral exercises Diagonal and rotational movements. Increased execution speed	2 to 4 sets of 30 to 60 s 5 to 7 repetitions	**Moderate** **Structured dual task:** Countdown Alternate motor patterns on cue Memorise sequences (A–B–C)	Spatial memory Motor learning Increase in BDNF and IGF-1
Phase 3 **Weeks 3 and 4** **Functional transfer and cognitive challenge**	Simulating everyday demands Integrating cognition, strength and postural control Maximising brain engagement	**Aquatic circuits:** Moving → pushing water → changing direction Reactive exercises Use of turbulence (partners, instructor) Rapid changes of pace	2 to 3 circuits 40 to 60s per station 6 to 8 repetitions (individualised)	**High** **Decision-making:** "If you hear X, change exercise" "Follow the correct colour" Response inhibition Spatial tasks	Consolidation of cognitive reserve Complex sensorimotor integration Transfer to DLAs

Example of an aquagym session

Hereunder is a suggested 40- to 45-minute session to be carried out in a shallow pool (Table 5).

Table 5. Example of an aquagym session with exercise descriptions.

Characteristics of the session	Description
Total duration	40 to 45 minutes
Weekly frequency	Two aquagym sessions per week
Water depth	From the level of the xiphoid process to the shoulder region
Warm-up (5–10 min)	Performing eight fundamental basic movements (running, kicking, turning, pendulum, scissor jumps, skiing, horse and rocking), combined with general mobility exercises and simple games, to activate the neuromuscular system and prepare the participant for the subsequent exertion.
Main part (25–30 min)	Performance of muscle strength and endurance exercises, integrated into progressive dual-task exercises and functional circuits, to simultaneously achieve physical, cognitive and functional benefits.
Cool-down (5–10 min)	Performance of slow movements, stretches and relaxation exercises, with an emphasis on emotional control and physiological recovery.

Conclusion

Current scientific evidence shows that sarcopenia and the decline in brain health, particularly in the hippocampus, are interrelated through common physiological mechanisms. Physical exercise, with an emphasis on strength training and structured aquagym, acts as an integrated intervention capable of improving muscle function whilst stimulating hippocampal plasticity. By promoting physical, cognitive and functional benefits safely and progressively, this approach effectively contributes to the maintenance of independence, cognition and quality of life during ageing.

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