

Effects of Aquatic Motor Intervention During Early-Childhood
and Adulthood on Motor, Cognitive and Language Abilities and
Changes in Temporoparietal and Cerebellar Alpha Power

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Abstract

Physical activity contributes to motor development and effects additional developmental aspects such as cognitive and language abilities. Although every individual has a unique developmental pattern, his/her development is influenced by the interaction between life experiences and the environment in which these experiences occur. Therefore, it is possible that changing the environment in which the activity occurs from on-land to aquatic, while using the unique characteristics of water, may lead to improvement in existing skills or even introduce new ones.

This research has two main objectives. First, to examine effects of aquatic motor intervention on motor, cognitive and language abilities, and the possible connection between these variables. Second, to examine neuro-biological mechanisms that might mediate between these abilities.

The research was conducted through two separate studies. The first study included 94 children between the ages of four to six: 31 children participated in the study group of Aquatic Motor Activities (AMA), 41 children participated in the first control group of On-Land Motor Activities (OLMA) that represented the motor aspect of the training without aquatic environment and 22 children participated in the second control group of Non-Motor Activities (NMA) that was controlled for the motor aspect of the training. Testing and data collection were conducted during personal meetings with the children prior to and after six months of a weekly training session. The developmental-functionality tests included:

- (1) Gross motor test: locomotion and object control (Hutzler, 1996 a, b).
- (2) Fine motor tests:
 - a. Finger-to-thumb test (Dow & Moruzzi, 1958).
 - b. Repetitive finger tapping test (Denckla, Rudel, Chapman & Krieger, 1985).
- (3) The time-estimation test (Nicolson, Fawcett & Dean, 1995).
- (4) Cognitive tests:
 - a. The Raven's Colored Progressive Matrices (RCPM) (Raven, 1965).
 - b. Processing speed tasks (visual matching and cross out tests) (Woodcock & Johnson, 1989).

(5) Language test: Rapid Automatized Naming (RAN) of objects and colors (Sahtil, 2002).

Participation in the aquatic and on-land motor activity groups during early-childhood was found to improve gross motor, time estimation and RCPM test scores. The AMA group achieved better improvement in these tasks than the NMA group. The OLMA group did not differ significantly from either group. Moreover, improvements in gross motor abilities of object control mediated the association between participation in AMA group and the improvement in the visual matching test. Improvements in time estimation test mediated the association between participation in AMA group and the improvement in the RAN of objects test.

Based on these findings and recent brain studies, we decided to examine the effects of aquatic motor intervention as compared to on-land motor and cognitive interventions on cognitive abilities and changes in temporoparietal and cerebellar alpha power. The second part of this study included 24 adults between the ages of twenty to forty: 8 adults participated in the study group of aquatic motor intervention, 8 adults participated in the first control group of on-land motor intervention and 8 adults participated in the second control group of non-motor intervention. Testing and data collection were conducted during personal meetings with the subjects at the Bar Ilan University, prior to and after 28 days of daily intervention. The tests included:

1) Cognitive test: The alternate uses (Guilford, Christensen, Merrifield & Wilson, 1978).

2) Language tests:

a. Digit Span Task (Friedmann & Gvion, 2003).

b. Rapid Automized Naming (RAN) of letters and numbers (Shany, Bahat, Lachman, Shalem & Zeiger, 2006).

In addition, we measured changes in temporoparietal and cerebellar alpha power using Magnetoencephalography (MEG).

Participation in the aquatic motor intervention group during adulthood was found to significantly improve performances in Digit Span Task. These results were accompanied by significant differences between the intervention groups in alpha

power in the left superior parietal lobule, the middle temporal gyrus and the right cerebellum. In addition, change in cerebellar alpha power was positively correlated with an improvement in the Digit Span Task.

These findings can improve the understanding of the relation between motor, cognitive and language abilities. Such understanding may contribute to improved early-childhood and adulthood intervention methods. Early-childhood interventions may assist in reducing primary differences and may also help avoiding additional developmental disorders. Moreover, the results support previous studies regarding the cerebellar region's role in motor skills and verbal working memory.