SIMULATED WEIGHTLESSNESS UNDERWATER: THE INFLUENCE OF NEUTRAL BUOYANCY ON WHOLE-BODY REACHING MOVEMENTS

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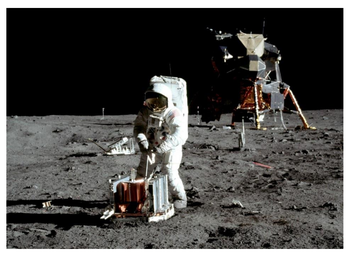
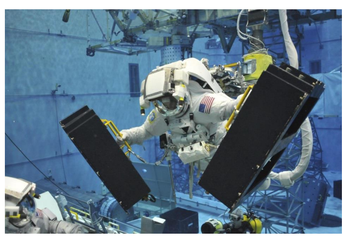
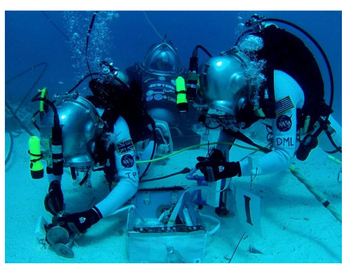
INTRODUCTION

Space missions & Extra-vehicular Activities (EVA)

During space missions, astronauts sustainably experience weightlessness on the International Space Station (ISS) or during Extra-Vehicular Activities (EVA), and must be ready to face other gravitational contexts such as on Moon and Mars surface for the upcoming decades of space exploration.







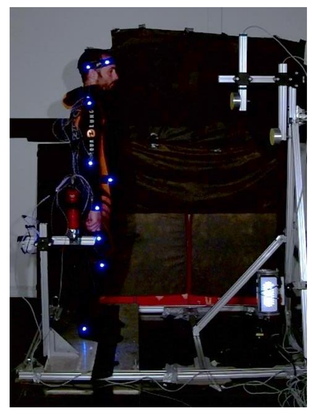
Intensive training underwater : “natural unweighting”

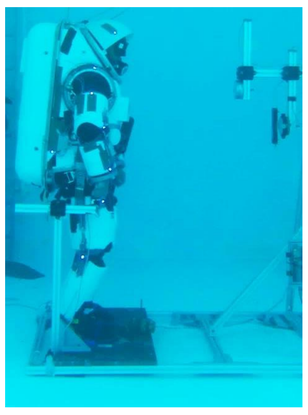
“EVA training underwater” exploits buoyancy (via the Archimedes principle) and provides “natural unweighting”. To approximate weightlessness, astronauts are immersed in training pools such that neutral buoyancy is usually applied to their Center of Mass (CoM). **Neutral buoyancy** is achieved when the upthrust exactly compensates for gravitational force.

Underwater environment : a good way to simulate weightlessness ?

METHODS

3 Environmental Conditions





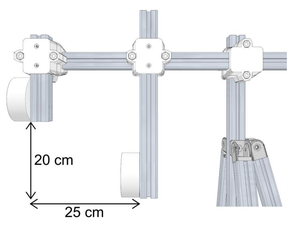
Land | **Aqua** | **AquaS**

2 Neutral Buoyancy Conditions

applied to : **CoM** | **Body Limbs**

Whole-body reaching movements:

2 target positions “Close“ and “Far”
Reaching movements with the arm outstretched

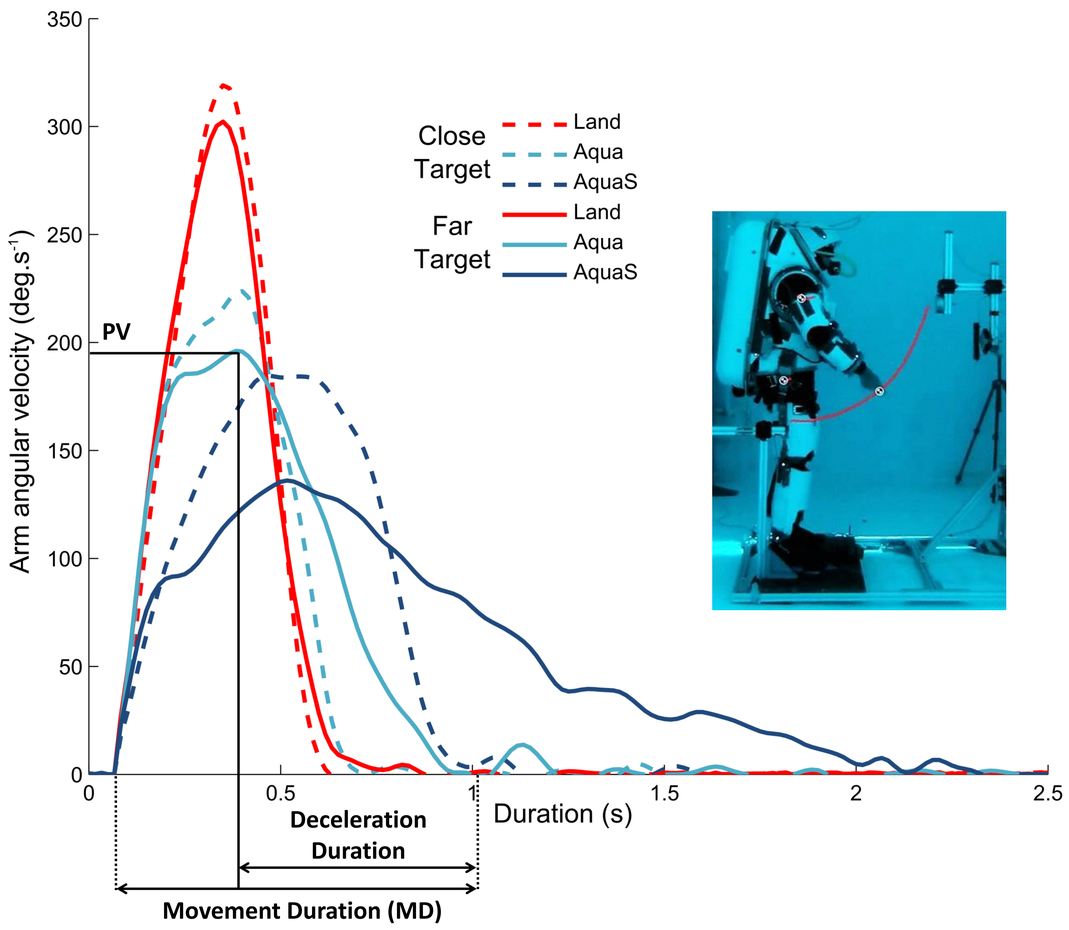


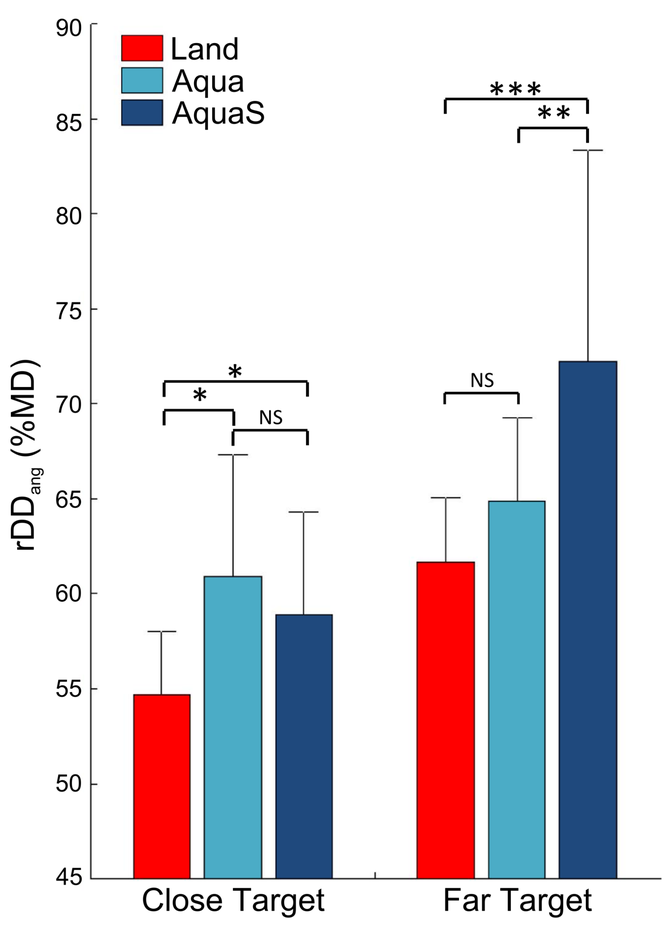
Focus on focal and postural component:

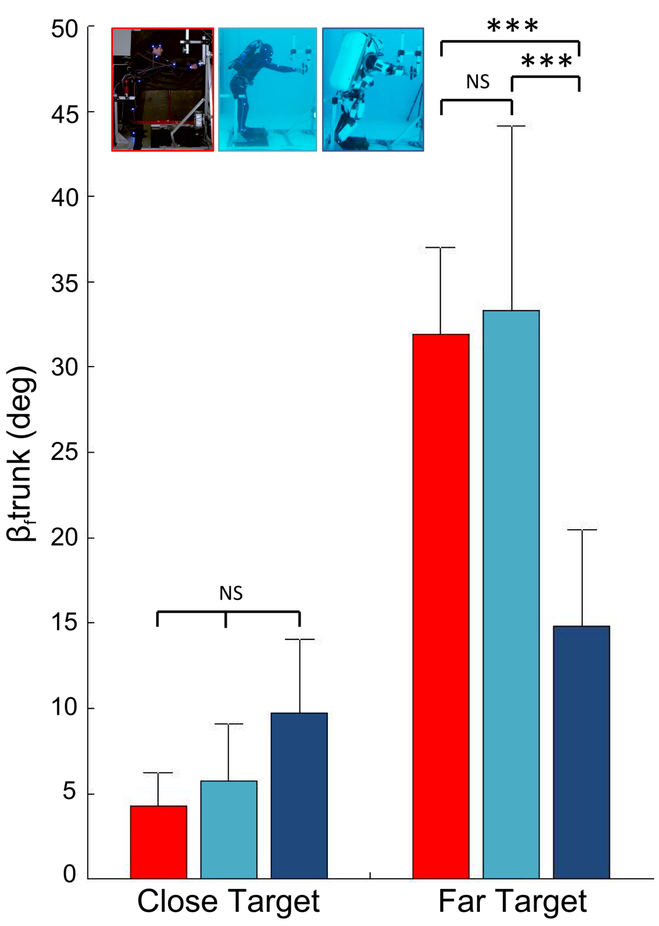
rDD_{ang}: relative Deceleration Duration of arm angular elevation (%Movement Duration)

$\beta_f$trunk: trunk flexion at movement end relative to vertical (deg)

RESULTS





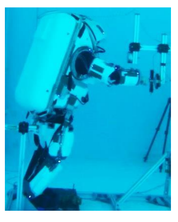


DISCUSSION

Underwater motor features with **neutral buoyancy on CoM**: focal and postural components were **closed to Land** Condition

Motor reorganizations associated to distributed neutral buoyancy across body limbs:
-Increase of the movement deceleration duration: **greater use of feedback processes** (Chua and Elliott, 1993)
-Whole-body forward displacement: **new postural strategy allowing efficient reaching** (Hilt et al., 2016)

Underwater environment may be a good way to simulate weightlessness BUT… …with a fine control of neutral buoyancy across the whole body enabling a better simulation of microgravity environments



Behavioral similarities

Bringoux et al., 2012
Casellato et al., 2012
(Parabolic Flights)

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