

BIOMECHANICAL AND PHYSIOLOGICAL EFFECTS OF SHALLOW WATER LOCOMOTION IN HEALTHY ADULTS

Michael Sola SPT, ATC, Micah Allison SPT, Megan Cusick SPT, ATC, Madison Franek SPT, Michael Murray PT, DPT, Derek Clewley PT, DPT, OCS, FAAOMPT

BACKGROUND

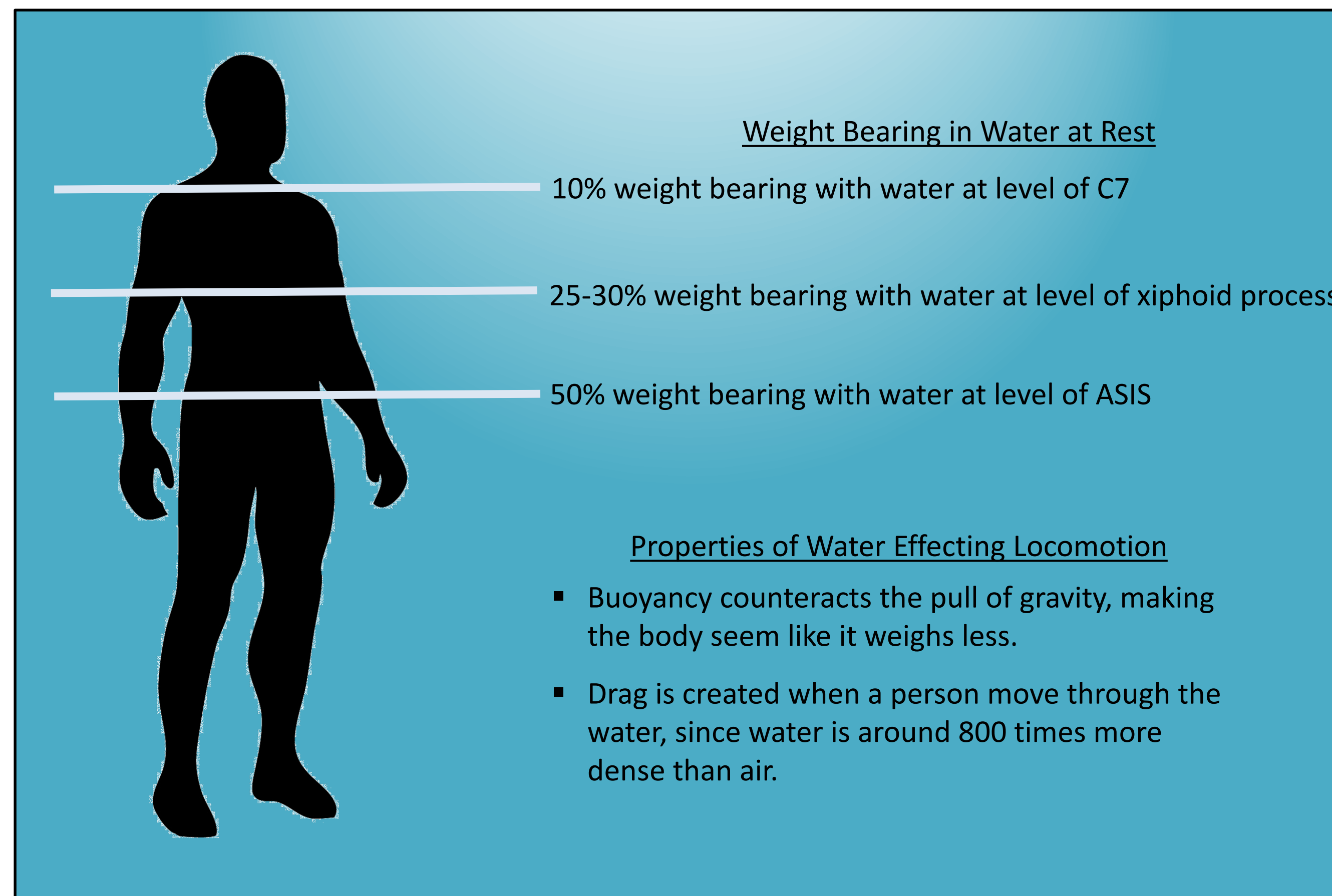
- Shallow water locomotion has become an increasingly popular intervention for rehabilitation of lower extremity injuries in healthy adults.
- There is a transfer of function when progressing from water to land based locomotion, despite there being a kinematical difference between the two environments.
- There are similar cardiovascular responses to shallow water locomotion when compared to land based locomotion.
- **Operational definition of shallow water locomotion:** any upright locomotion in a body of water, neck deep or lower, in which the foot contacts the bottom surface to propel a person's body through water, or over a treadmill.
- There is limited research exploring biomechanical and physiological effects of shallow water locomotion and how these variables may be interrelated.

PURPOSE

- To provide a review of the biomechanical and physiological effects of shallow water locomotion in healthy adults.

METHODS

- Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to identify articles to be reviewed.
- **Search Terms:** aquatic, hydrotherapy, shallow water, locomotion, running, exercise, treadmill, physiology, heart rate, oxygen consumption, physical exertion, biomechanics, ground reaction force, stride.
- **Eligibility Criteria:**
 - English full text manuscripts that examined biomechanical and/or physiological variables of shallow water locomotion of healthy adults.
 - Articles were excluded if subjects performed stationary movements or used a flotation device.



RESULTS

- 1836 articles were retrieved from PubMed, CINAHL, and Embase. 21 articles were acceptable for data extraction.
- **Stride Length and Stride Frequency**
 - Stride frequency and length both decreased leading to significantly lower self-selected walking speeds compared to land.
- **Ground Reaction Forces (GRF)**
 - Vertical GRF was decreased in water compared to land and decreased at higher levels of immersion.
 - Horizontal GRF decreased in water compared to land and increased with speed and lower water levels.
- **Joint Mechanics**
 - Hip flexion had similar total range of motion, but occurred in a more flexed trunk position.
 - The knee had decreased total range of motion and occurred in a more flexed position.
 - The ankle had similar total range of motion, but occurred in a more dorsiflexed position.
- **Physiological Variables**
 - Heart rate had a linear response to increasing intensity in water.
 - Heart rate and VO₂ had a similar relationship in water compared to land.
 - RPE and heart rate had a linear relationship in water and land.

CONCLUSIONS

- The evidence suggests that shallow water locomotion can be used to decrease the forces associated with locomotion while maintaining the physiological benefits of exercise.

CLINICAL RELEVANCE

- The properties of water decrease the forces on the body, while potentially increasing muscle power and speed.
- Training in an aquatic environment is a viable option to maintain or improve cardiovascular fitness if land based locomotion is contraindicated because of high biomechanical stress on the body.
- Community pools may serve as an accessible way to utilize the biomechanical and physiological benefits of shallow water locomotion.



ACKNOWLEDGEMENTS / REFERENCES

- We would like to thank Leila Ledbetter and Brandi Tuttle for their assistance in developing a search strategy.
- 1. Becker BE. Aquatic therapy: scientific foundations and clinical rehabilitation applications. *PM R*. 2009;1:859-872.
- 2. Fantozzi S, Giovanardi A, Borra D, Gatta G. Gait kinematic analysis in water using wearable inertial magnetic sensors. *PLoS ONE*. 2015;10:
- 3. Kato T, Onishi S, Kitagawa K. Kinematical analysis of underwater walking and running. *Sports Medicine, Training and Rehabilitation*. 2001;10:165-181.
- 4. Masumoto K, Hamada A, Tomonaga HO, Kodama K, Hotta N. Physiological responses, rating of perceived exertion, and stride characteristics during walking on dry land and walking in water, both with and without a water current. *Journal of sport rehabilitation*. 2012;21:175-181.