Aquatic Rehabilitation for the Shoulder, Lower Extremity and Trunk utilizing the Aquatic Biofeedback/EMG Technique

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Biofeedback/EMG

• Definition:
  EMG – the sum of the energy from all muscle action potentials detected by the recording electrode.
  Biofeedback – a training program in which a person is given information about physiologic processes (muscle recruitment, heart rate or blood pressure) that is not normally available with the goal of gaining conscious control of them.

Aquatic Biofeedback/EMG

• Definition - the utilization of land-based biofeedback and sEMG techniques and theory, adapted to the aquatic environment, taking into consideration hydrodynamic principles, in order to give aquatic therapists more useable feedback to enhance patient rehabilitation. It can also be used to validate aquatic techniques and treatments.
Benefits of Aquatic Biofeedback/EMG

- 1. More control of patient exercise
- 2. More specificity of muscles exercised
- 3. Quantitative data
- 4. Ability to customize exercise routine

Past and Current Research in Aquatic Biofeedback/EMG for the Shoulder, Lower Extremity and Trunk

- "Fine wire electromyography analysis of muscles of the shoulder during swimming". Nube, Jobe, et al 1986 JOSPT
“Shoulder Muscle Activation During Aquatic and Dry Land Exercises in Nonimpaired Subjects”.

Kelly, Roskin, et al. JOSPT 2000

- 6 muscles studied: supraspinatus, infraspinatus, subscapularis, anterior, middle, and posterior deltoids.
- EMG data gathered on shoulder elevation (scapular plane) from 0°-90° at 30°/sec, 45°/sec, and 90°/sec.
- Findings showed lower EMG signals at the two slower speeds compared to the same movement on land.
- Active shoulder motion in water can be performed with decreased muscle activation on the rotator cuff and shoulder girdle muscles.
- Supports the use of aquatic therapy for safe, early active motion of the shoulder.

Lower Extremity Research


Lower Extremity Research

“The activity levels of the VMO muscle during a single leg squat on the land and at varied water depths.” Fuller, Awbrey, et al. *APTA Aquatic Journal* 1999

- 51 subjects tested at three levels: on land, in waist deep and chest deep water.
- Muscular activity generated in waist deep water was 50% of that generated on land. Chest deep was 25% of the land values.
- Proved that combining aquatic biofeedback and closed-chain exercises provided greater control, decreased pain and flexibility to the therapist which allowed rehabilitation to start sooner.
- Study showed that aquatic biofeedback was a valid and reliable rehabilitative tool.

“Loading of the lower limb when walking partially immersed: implications for clinical practice”. Harrison, Hillman and Bulstrode. *Physiotherapy* 1999

- Compared weight bearing in standing, slow and fast walking.
- Used water-proofed force plates submerged in water.
- “Standing (static)” percentages equal to our findings.
- Established standards for aquatic ambulation vs. weight bearing restrictions.

**Trunk Research**

An Aquatic and Land-Based Physical Therapy Intervention to Improve Functional Mobility for an Individual after an Incomplete C6 Spinal Cord Lesion

- Functional improvement possible after one year post injury.
- Functional improvement was shown to occur in the absence of increasing MMT scores (although sEMG scores increased).
- The aquatic environment proved to be a logistically efficient method of incorporating multiple therapeutic activities within the time constraints of a single therapy session.
- Further research is needed to identify the clinical role of sEMG measurements in the rehabilitation of this patient population.

Traditional locomotor recovery theory in SCI
- Gait training – full weight bearing (FWB) with AD
- "What you have after one year is what you get"
- MMT plateau supported this clinical reasoning

"Newer" locomotor recovery theory in SCI
- "Central Pattern Generator" (CPG)
- Body weight support treadmill training (BWST)
- Locomotor recovery possible after one year mark

INTERVENTION:
- **Land:** sit-stand transfer training, FWB gait training with a rolling walker.
- **Aquatic:** Bad Ragaz exercises, CKC lower extremity exercises, aquatic biofeedback training, reciprocal gait training in deep water and ambulation with assistance in waist deep water.
- **Duration/Frequency:** 50 minute treatment sessions, 2x/wk for 4 months
OUTCOMES - AMBULATION

Pre-Intervention | Post-Intervention
--- | ---
35 | 35
7 | 7

(Mod A x 2) | (Min A x 1)

OUTCOMES - MMT

ASIA Motor Score

Right LE | Left LE | Combined LE
--- | --- | ---
13 | 5 | 18
12 | 6 | 17

Pre-Intervention | Post-Intervention

OUTCOMES - sEMG

sEMG Recording (mV)

Pool | Land | Combined Pool/Land
--- | --- | ---
451 | 600 | 1010
600 | 410 | 600
241 | 1010 | 241

Pre-Treatment | Post-Treatment
Introduction

- The purpose of this case report is to investigate the effect of the outer core muscles involvement with functional activities both on land and in the water and to better determine which specific aquatic exercises facilitate these muscles to achieve maximum benefit.

- LBP remains one of the major healthcare issues in the U.S.
- Aquatic Therapy continues to be one of the fastest growing disciplines of Physical therapy
- Aquatic Therapy is recommended and often utilized in the treatment of back pain
- Aquatic Therapy is a therapeutic medium that offers the physical properties of buoyancy, decreased joint compression and improved motor learning response.
Introduction

- Much effort has been made to study the deep core muscles, but little has been done in the way of superficial core muscles and their role in functional activity in water.

Subject

- 29 y.o. male with no significant PMH.
- Selection of convenience
- Height 6'1"
- Weight 185lbs

Instruments

- ProComp EMG unit with eight (surface EMG) channels by Thought Technology, LTD in Montreal, Canada
- Infinity software
- Myoscan- Pro electrodes
- Tegaderm™ bioclusive dressings
- Alcohol wipes
- Metronome
Application

- Skin preparation
- Electrode placement on Rectus Abdominus, Gluteus Medius, and Gluteus Maximus bilaterally.
- Performed exercises to ensure proper placement:
  - Abdominus- standing pelvic tilt
  - Gluteus Medius- standing hip abduction
  - Gluteus Maximus- Standing leg extension

Electrode Placement

- Rectus Abdominus
  - Two electrodes were placed 3cm apart and parallel to the muscle fibers, so that they are located approx 2 cm lateral and across from the umbilicus over the muscle belly
Electrode Placement

- **Gluteus Medius**
- After palpation of the iliac crest. Two active electrodes 2cm apart are placed parallel to the muscle fibers over the proximal third of the distance between the iliac crest and the greater trochanter.

Electrode Placement

- **Gluteus Maximus**
- Targeting the upper muscle fibers two electrodes 3cm apart are placed half the distance between the greater trochanter and the sacral vertebrae, in the middle of the muscle on an oblique angle at the level of the trochanter.
**Exercises**

- Performed 4 exercises both on land and then in the water. A metronome was used to maintain a constant beat every three seconds.
- Exercises were:
  - Sit to stand
  - Step up and down
  - Cube position push/pull
  - Alternating Hip flexion and extension (straight leg)

**Results: Sit to Stand (land)**

- Substantial abdominal recruitment was revealed during both the "sit" and the "stand" phase.
- The right gluteus medius muscle demonstrated less recruitment than the left.
- The right gluteus maximus muscle and the left showed the same recruitment configuration as the abdominals.
Results: Step up/down (land)

- The rectus abdominus muscle again was recruited more than the gluteus medius and maximus during step up and downs.
- The gluteus medius revealed more recruitment than that of the gluteus maximus.

Results: Push/pull (land)

- The rectus abdominus muscles demonstrated increased recruitment during the pushing phase.
- The gluteus medius and maximus showed lower but consistent values throughout the specified movement.

Results: alternating flexion/extension (land)

- The gluteus medius and the gluteus maximus muscles showed consistent recruitment.
- The rectus abdominus again showed higher output.
Results: sit to stand (pool)

- The effects of buoyancy start to affect the data.
- The rectus abdominus still exhibited strong, consistent recruitment throughout the movement.
- The gluteus medius and maximus displayed low recruitment rates.

Results: step up/down (pool)

- The rectus abdominus, and Gluteus Maximus muscles produced a constant low mean recruitment value.
- The gluteus medius produced the most recruitment.
Results: cube position push/pull (pool)

- The rectus abdominus muscle showed alternating low contraction and relaxation.
- The gluteus maximus and medius muscles showed somewhat static contractions throughout the movement.
Results: Alternating hip flexion and extension (pool)

- The rectus abdominus showed an almost static contraction throughout the movement pattern.
- The left gluteus medius muscle showed a more active recruitment pattern than the right.
- The gluteus maximus revealed low recruitment values.
Discussion

• Increased rectus abdominus recruitment on land over water may have been due to increased need to stabilize the trunk where as buoyancy and hydrostatic pressure reduced the need for recruitment.
• Gluteus Medius was recruited more than Gluteus Maximus in all exercises. We believe this may be due to underlying water currents and their effect on LE medial/lateral stability.

Discussion

• A significant difference was noted in muscle recruitment throughout the four pool exercises as compared to land exercises (gravity vs. buoyancy).
• Significantly less “effort” was noted by the subject when performing the pool exercises.
• Land based exercises were able to solicit a higher muscle recruitment than water based.

Discussion

• Consistent muscle recruitment was noted with all pool exercises for all muscle groups.
• Training in the aquatic environment may enhance the consistent recruitment abilities of these three muscle groups while allowing the patient to feel more comfortable while exercising.
Limitations

- 1 subject (only).
- Performed first on land and then in water. Should have considered comparing water then land for a second exercise bout to see if this made a difference.
- Compared land vs. water (perhaps water vs. water after a training regimen in the pool would have shown a greater recruitment level as compared to land).
- Erector Spinae group was excluded from trial.

Aquatic Biofeedback/EMG Technique

Considerations

- Cross talk
- Lights
- Not able to access all muscles (specific, quasi specific)
- Water infiltration
- Hydrodynamic principles
- Treading where few have trodden
- Water and electricity
- Computers/Water/EMG equipment, oh my!!!
Initial Setup

- Refer to an electromyography manual to assure proper placement of electrodes as well as direction of muscle fibers ("Introduction to Surface Electromyography" by J. Cram and G. Kasman).
- Palpate bony landmarks to assure proper placement/direction of electrodes.
- Prepare the skin with alcohol wipe to remove any oils, dirt or lotions.

Apply Electrodes

- Apply electrode to muscle belly (according to EMG manual).
- Active electrodes should be lined up parallel with the muscle fibers.
- Plug lead wires into EMG unit, turn on unit.
- Contract muscle – observe on unit.

Apply Bioclusive Dressing
Apply AquaSense™ Sock

Shoulder Rehabilitation

Lower Extremity Rehabilitation
Trunk Rehabilitation

Future Aquatic Biofeedback/EMG Projects

- “Wireless” aquatic rehabilitation.
- Multi-site research projects.
- More aquatic-friendly biofeedback equipment.
- On-line aquatic biofeedback/EMG courses.

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