Gait and balance parameters improvements in adolescents with developmental disorders after an 8-week Aquatic Therapy Program

Dr. Mariana C. Kotzamanidou PT, PE
Lecturer
Dept. of Physiotherapy,
Akmi Metropolitan College Thessaloniki
Gait & Balance improvements in adolescents with Aquatic Therapy

Panoutsakopoulos V, Aggeloudis K, Kollias IA
Dept. P.E. Sports Sci, Aristotle University of Thessaloniki

Avramidou E
1st University Psychiatric Clinic, Papageorgiou Hospital

Zafeiriou I
Medical School, Aristotle University of Thessaloniki

Manavis K
Hellenic National Health System, Thessaloniki

Lambeck J
Katholieke Universiteit Leuven
Activities of Daily Life (ADL): walking, balance, obstacle avoidance, sit-to-stand, stair ascending/descending ...

ADLs can be assessed biomechanically

Data can be retrieved from force plates, EMG recordings, video analysis, goniometers, accelerometers...
The main interest was to assess possible alterations in ADLs execution by children between 7-15 years old after Aquatic Therapy Programs (AqTP) including various therapeutic interventions such as Bad Ragaz, Water Specific Therapy and Clinical Ai Chi.

A previously published review reported that mix intervention types are a common ground for Aquatic Therapy in children.

Karklina et al. (2013)
Purpose of the study:

To present the alterations in key biomechanical gait and balance parameters in four case studies after AqTP.
Case study #1:

- A.S. (13.1 yrs, 1.79 m, 75.8 kg, 23.7 kg/m²)
- slow starter - mental impairment
- Parental consent ✓
Case study #2:

- T.S. (14.9 yrs, 1.74 m, 61.9 kg, 20.4 kg/m²)
- Loose ligaments
- Parental consent ✓
Case study #3:

- K.P. (15.5 yrs, 1.58 m, 65.8 kg, 26.4 kg/m²)
- Congenital scoliosis - lumbar vertebras synostosis
- Parental consent ✓
Case study #4:

- L.M. (6.4 yrs, 1.28 m, 25.3 kg, 15.4 kg/m²)
- Frontal lobe dysfunction – mental impairment
- Slow speech response
- Parental consent ✓
Methodological approach:

1. clinical evaluation
2. initial biomechanical assessment
3. implementation of an 8-week ATP
4. post-intervention biomechanical assessment

1 2 3 ← 8w Aquatic Therapy → 4
**Intervention**

- **AqTP**
  - **Water Depth**
    - Knee → Hip
  - **8 weeks**
  - **2/week**
  - **60´ session**
  - **Water temperature**
    - 28°C
  - **Private pool**
  - **Water specific therapy**
  - **Clinical Ai Chi**
  - **Bad Ragaz Ring Method**
  - **Bad Ragaz Ring Method**
  - **Knee**
  - **Bad Ragaz Ring Method**
  - **Knee**

**Kotzamanidou et al.: Gait & Balance improvements in adolescents with Aquatic Therapy**
Kotzamanidou et al.: Gait & Balance improvements in adolescents with Aquatic Therapy
Biomechanical Analysis: Gait

- 3 successful trials (averaged)
- Ground reaction forces from 2 force plates
- AMTI OR6-5-1 force-plate (AMTI, Newton, MA)
- Custom made force-plate (©: Iraklis A. Kollias)
- $S_f$: 1kHz
Gait & Balance improvements in adolescents with Aquatic Therapy

Kotzamanidou et al.

Fz = 0

Fz = mass

Fz₁ = -0.01
Fzₗ = 0.62
Fz = 0.70
Drop = 0.96

(right leg support)

Braking phase

Propulsion phase

(left leg support)

double support
Biomechanical Analysis: Balance

- bipedal upright posture, single support, Romberg Balance Tests (open/closed eyes)
- duration: 10 sec
- Separate force data collection for each leg
- 2D-DELTA Stabilometer (©: Iraklis A. Kollias)
- $S_f$: 50 Hz
Kotzamanidou et al.: Gait & Balance improvements in adolescents with Aquatic Therapy

95% ellipse; medio-lateral (M-L) axis

95% ellipse; anterior-posterior (A-P) axis

95% amplitude; vertical Ground Reaction Force

Stabilogram 

Speedogram 

Force - Time history (Newton)

ISORROPIES (@2004 by I.A.K.) 01-26-2011 @ 10:53:33

DATA - File: c:\balance\229x10\15376a - Time: 01-19-2011 @ 19:40:54

8191

90\% (F 30.1\%) (X 30.9\%) (Y 21.1\%) 
95\% (F 58.6\%) (X 56.6\%) (Y 49.2\%) 
99\% (F 91.4\%) (X 89.8\%) (Y 88.3\%)

Stabilogram Surface (mm²) [all = 676.7] [sd = 105.6]
Statistical Analysis:

Due to the limited number of participants, descriptive statistics were utilized for presenting pre- and post-intervention differentiations in the examined biomechanical parameters.
RESULTS
## Balance tests

A 95% ellipse [quite stance]

<table>
<thead>
<tr>
<th>sub</th>
<th>X-axis: pre (mm)</th>
<th>X-axis: post (mm)</th>
<th>%Δx(post-pre)</th>
<th>Y-axis: pre (mm)</th>
<th>Y-axis: post (mm)</th>
<th>%Δy(post-pre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs#1</td>
<td>5.3</td>
<td>3.2</td>
<td>-39.6</td>
<td>4.9</td>
<td>2.6</td>
<td>-46.9</td>
</tr>
<tr>
<td>cs#2</td>
<td>5.3</td>
<td>3.2</td>
<td>-39.6</td>
<td>7.3</td>
<td>3.9</td>
<td>-46.6</td>
</tr>
<tr>
<td>cs#3</td>
<td>3.7</td>
<td>2.4</td>
<td>-35.1</td>
<td>4.1</td>
<td>3.5</td>
<td>-14.6</td>
</tr>
<tr>
<td>cs#4</td>
<td>5.7</td>
<td>3.1</td>
<td>-45.6</td>
<td>8.9</td>
<td>4.3</td>
<td>-51.7</td>
</tr>
</tbody>
</table>

mean: **-40.0%**

mean: **-40.0%**
balance tests: quite stance - vGRF

[Graph showing data for pre and post tests]
Gait & Balance improvements in adolescents with Aquatic Therapy

balance tests: quite stance – Center of Pressure

![Graph showing balance tests](image)
balance tests: Single Support - vGRF
balance tests: Single Support – CoP
Gait analysis

pre- and post-intervention comparisons (%)

<table>
<thead>
<tr>
<th>sub</th>
<th>Tcontact</th>
<th>Tdouble sup</th>
<th>TFzBraking</th>
<th>TFzMin</th>
<th>T%braking</th>
<th>TFzPropult</th>
<th>FzBraking</th>
<th>FzPropult</th>
<th>Impulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs1</td>
<td>2.7</td>
<td>-19.8</td>
<td>-36.3</td>
<td>-36.4</td>
<td>12.7</td>
<td>24.9</td>
<td>0.9</td>
<td>-2.6</td>
<td>19.4</td>
</tr>
<tr>
<td>cs2</td>
<td>-3.9</td>
<td>12.4</td>
<td>11.4</td>
<td>-17.3</td>
<td>4.9</td>
<td>8.4</td>
<td>14.1</td>
<td>12.7</td>
<td>14.0</td>
</tr>
<tr>
<td>cs3</td>
<td>-23.3</td>
<td>15.6</td>
<td>6.8</td>
<td>-15.1</td>
<td>15.4</td>
<td>8.0</td>
<td>6.8</td>
<td>12.4</td>
<td>39.0</td>
</tr>
<tr>
<td>cs4</td>
<td>-47.7</td>
<td>40.1</td>
<td>26.7</td>
<td>-18.8</td>
<td>-21.3</td>
<td>21.0</td>
<td>29.3</td>
<td>27.4</td>
<td>0.0</td>
</tr>
<tr>
<td>mean</td>
<td>-18.1</td>
<td>12.1</td>
<td>2.1</td>
<td>-21.9</td>
<td>2.9</td>
<td>15.6</td>
<td>12.8</td>
<td>12.5</td>
<td>18.1</td>
</tr>
</tbody>
</table>
Ground Reaction Forces: anteroposterior direction

Fx-R-pre
Fx-R-post
Fx-L-pre
Fx-L-post
Ground Reaction Forces: mediolateral direction

- Fy-R-pre
- Fy-R-post
- Fy-L-pre
- Fy-L-post
Results summary: pre-post comparisons

- M-L & A-P stability: ↑ 40% in quite stance balance
- ↓ 18% faster step time
- ↑ 2% elongation of braking phase
- ↑ 10% time to reach maximum vGRF
- ↑ 9% [ × body mass] vGRF at heel contact
Discussion

The Aquatic Therapy program that was implemented:

- improved proprioception ability
- established a smoother GRF walking pattern
- established a more optimal heel-to-toe transition
- did not resulted in improvements single stance balance test performance
Kotzamanidou et al.: Gait & Balance improvements in adolescents with Aquatic Therapy
4 different cases studies

Every cases different but the common factor was
The disorders and the deficits of the children were

Diagnosis:
1. Disorders on the frontal lobe and low mentality
2. Congenital scoliosis and lumbar vertebra were added
3. Patella dislocation during football training
4. Slow starter
## Gait analysis

<table>
<thead>
<tr>
<th>GAIT PARAMETERS</th>
<th>RIGHT LEG</th>
<th>LEFT LEG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PRE</td>
<td>POST</td>
</tr>
<tr>
<td></td>
<td>Force</td>
<td>Time</td>
</tr>
<tr>
<td>Conduct time (T)</td>
<td>1015</td>
<td>↓ 617</td>
</tr>
<tr>
<td>Double Support</td>
<td>26%</td>
<td>13.48</td>
</tr>
<tr>
<td>$F_{\text{2 max}}$ (braking phase)</td>
<td>103.2</td>
<td>↑ 108.98</td>
</tr>
<tr>
<td>$F_{\text{2 min}}$</td>
<td>89.5%</td>
<td>41.2%</td>
</tr>
<tr>
<td>Change of Direction</td>
<td>59.8%</td>
<td>↓ 52.58</td>
</tr>
<tr>
<td>$F_{\text{2 max}}$ (propulsion)</td>
<td>95.6%</td>
<td>↑ 97.48</td>
</tr>
<tr>
<td>mean ratio $F_{\text{2}}/\text{BW}$</td>
<td>71.1%</td>
<td>81.98</td>
</tr>
</tbody>
</table>

($^\circ$) **FORCE** = reference: body mass
($^\circ$) **TIME** = reference: conduct time
Conclusion
Gait & Balance improvements in adolescents with Aquatic Therapy

Kotzamanidou et al.