A graduate of Tulane University School of Medicine, Dr. Becker completed his residency training in Physical Medicine and Rehabilitation at the University of Washington. Prior to moving to Spokane, he is a Clinical Professor in the Department of Rehabilitation Medicine at the University of Washington School of Medicine, and also serves as Research Professor at Washington State University, where he is Director of the National Aquatics and Sports Medicine Institute, pursuing physiologic research during aquatic activity.

He has a major interest in aquatic rehabilitation, and is President of the American Society of Medical Hydrology. In 1997, Dr. Becker and Andrew Cole, MD co-authored the textbook Comprehensive Aquatic Therapy, which was also published in Portuguese and German. The second edition of the textbook was published in 2002, and a third edition was published in 2011 by Washington State University Press. He has authored chapters on aquatic therapy in most of the leading textbooks in rehabilitation, published aquatic research articles in numerous journals and lectured nationally and internationally in the area of aquatics. Dr. Becker has been honored by his peers every year from 1998 to the present through his selection to the Best Doctors in America: Physical Medicine & Rehabilitation listings. In 1999, the Aquatic Therapy and Rehabilitation Institute named Dr. Becker as Aquatic Professional of the Year at their annual meeting in San Diego. Aquatics International Magazine named him to the Power 25 in Aquatics in 2006 and again in 2011. He is to be inducted into the International Swimming Hall of Fame in May 2011 for his work in adapted aquatics. He is the recipient of major aquatic research grants from the National Swimming Pool Foundation.

Abstract

Cardiovascular disease is one of the most prevalent chronic diseases in America and poses huge economic burdens on our health care system. Aquatic exercise produces physiologic effects that may be quite beneficial in this group of diseases, yet the effects of aquatic exercise are neither widely understood as valuable nor widely utilized. Many of the same physiologic effects that impact the cardiac system are potentially beneficial in the management of chronic kidney disease. There is a wealth of recent research supporting value for aquatic exercise that will be presented, with guidelines for the aquatic practitioner.
AQUATIC EXERCISE IN HEART & KIDNEY DISEASE

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Aquatic Forces & Physiology

$\Delta P = \rho g \Delta h$
$Q = mc\Delta T$
$Re = \frac{2
\nu r p}{\eta}$
$P_d = k v^3$

Cardiac Physiology
Pulmonary Physiology
Renal Physiology
Neurophysiology
MSK Physiology

Normal Cardiac Function
Cardiac Changes during immersion

Water Immersion to chest or higher

- Increased hydrostatic pressure
- Venous compression
- Lymphatic compression
- Central blood volume increases
- Atrial pressure rises
- Pulmonary Artery pressure rises
- Cardiac volume increases
- Stroke volume increases
- Cardiac output increases
CORONARY HEART DISEASE RISK FACTORS

- Low Maximal Aerobic Capacity (Cardiorespiratory fitness CRF)
- Increased Arterial Blood Pressure (both systolic & diastolic)
- Abnormal Blood Lipids and Lipoproteins
- Abnormal CHO Metabolism & Insulin Sensitivity
- Excessive Bodyweight and Fatness

Impact of swimming on mortality risk in men

Cooper Institute Aerobics Center Longitudinal Study 1971-2003
3,386 deaths during 543,330 man-years of exposure

- Sedentary: 56%
- Walkers: 51%
- Runners: 47%

National Swimming Pool Foundation ∙ 4775 Granby Circle ∙ Colorado Springs, CO 80919 ∙ (719)540-9119 ∙ www.nspf.org
Maximal Aerobic Capacity

Cardiorespiratory Fitness (CRF)

- Independent risk factor for cardiovascular and all-cause mortality
- More important than smoking, obesity, diabetes, high lipids & hypertension
- Low values associated with risk of disability, decreased cognitive function & quality of life

CORONARY HEART DISEASE RISK FACTORS

Blood Pressure Elevation

- Most studies show immersion to produce a transient reduction in BP and peripheral vascular resistance
- Regular aquatic exercise may decrease BP in hypertensive pts.
- Interestingly, a few studies have shown that regular swimmers show a slight elevation in both systolic and diastolic pressures (still within normal range) compared to land exercisers, and other studies have shown reduction in resting pressures

Hypertension & Hot Tubs

Water temperature = 40° C

- Immersion period
- Blood pressure (mm Hg)
- Immersion time in minutes
### CORONARY HEART DISEASE RISK FACTORS

#### Serum Lipids
- Dyslipidaemia has long been associated with development of coronary heart disease
- Regular exercise produces an increase in HDL-C and decrease in triglycerides
- Regular aquatic exercisers typically show lower total cholesterol and LDL-C levels, but there seems to be less effect upon HDL-C levels, unlike age-matched runners

#### Carbohydrate metabolism and insulin sensitivity
- Insulin resistance typically precedes Type 2 Diabetes
- Aquatic exercisers have shown increased insulin sensitivity and lower fasting insulin levels, even despite increased % body fat
- In Type 1 Diabetes, regular swimming has shown a reduction in hemoglobin A1c and reduction in glycated hemoglobin in Type 2 DM
- This suggests that regular aquatic exercise may have a beneficial effect upon glycemic control and reduce risk of diabetes

#### Body Weight and % Body Fat
- Competitive swimmers have higher % body fat than competitive land endurance athletes. This is especially pronounced in ultra-endurance athletes
- Several studies have shown no significant effect upon weight or % body fat in longer term aquatic exercisers and swimmers
- Work in our lab at WSU showed comparable reduction in weight and % body fat in a cohort of aquatic exercisers compared to land exercisers over a 15 week exercise intervention
Comparative % of Overweight body mass

BMI 25.0-29.9
Cooper Institute Aerobics Center Longitudinal Study 1970-2005

Chase, Sui, Blair: Comparison of the Health Aspects of Swimming with Other Types of Physical Activity and Sedentary Lifestyle Habits, IJARE, (2) 2008

Relationship between % Max O2 Uptake Reserve, % Max HR & RPE

CRF and Aquatic Exercise

• At similar intensity, duration and frequency water exercise is equivalent to land exercise in CRF benefit, strength, lipid alterations, and body composition

• A 40-min. session of aquatic exercise can easily achieve a training intensity level sufficient to gain the health benefits of exercise (50-65% of Peak MET’s, 65-70% Max heart rate)

• Shallow and deep water exercise both can provide this benefit

• Interestingly, trained swimmers show increased CRF, but poorer treadmill performance than trained runners.
**Congestive Heart Failure**

**Classification of Heart Failure**

New York Heart Association

<table>
<thead>
<tr>
<th>Class</th>
<th>Patient Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I (Mild)</td>
<td>No limitation of physical activity. Ordinary physical activity does not cause fatigue, palpitation, or dyspnea (shortness of breath).</td>
</tr>
<tr>
<td>Class II (Mild)</td>
<td>Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in fatigue, palpitation, or dyspnea.</td>
</tr>
<tr>
<td>Class III (Moderate)</td>
<td>Marked limitation of physical activity. Comfortable at rest, but less than ordinary activity causes fatigue, palpitation, or dyspnea.</td>
</tr>
<tr>
<td>Class IV (Severe)</td>
<td>Unable to carry out any physical activity; without discomfort, symptoms of cardiac insufficiency at rest. If any physical activity is undertaken, discomfort is increased.</td>
</tr>
</tbody>
</table>

**Aquatic Therapy Effects on CHF**

Neck depth immersion at 41°C (105.8°F)

- 70
- 60
- 50
- 40
- 30
- 20
- 10

4 week therapy course
Aquatic Exercise in CHF

25 pts with CHF (15 treated, 10 controls) 8 weeks training at 3 times/week, 45 min/session at 40-70% HRR

Warm Water Immersion in CHF

13 subjects, 13 controls, 33-34°C in-pool echocardiography

A Clinical Algorithm for Aquatic Activity Decision-Making
Swimming and the Cardiac Patient

- Swimming produces a highly variable exercise response
  - Skill levels vary widely
  - Upper body strength is critical, producing increasing cardiac demand
  - Failure to identify symptoms of ischemia are worrisomely common
  - Asymptomatic ischemia may lead to potentially dangerous arrhythmias
- Thus, swimming should be recommended with caution in the cardiac patient, esp. those with ST-depression & limited skills.

Immersion, Exercise and the CHF Patient

- For NYHA Class I, II and III candidates, an aquatic exercise program seems to be well tolerated and beneficial
  - Precautions: recent infarct (<3 mo.), unstable rhythm disorders, uncompensated failure or active myocarditis
  - Such programs can improve strength and endurance, reduce CHF symptoms, and QOL
  - Many physicians are unaware of this potential benefit

Aquatic Forces & Physiology

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\[ P_d = k \nu^3 \]
• 28. Schega L, Claus G, Almeling M, Niklas A, Daly DJ. Cardiovascular responses during thermoneutral, head-out water immersion in patients with coronary artery disease. J...