BENDING THE AGING CURVE:
A periodized prescription for improved aging

Joseph Signorile, PhD
THE NEUROMUSCULAR CURVES

(a) Muscle area (mm²/48) vs. Age (years) with P < 0.001

(b) Total number of fibers (10³) vs. Age (years) with P < 0.001

(c) Fiber diameter (µm) vs. Age (years) with p < 0.05

Type I fiber
Type II fiber
CONNECTIVE TISSUE CURVES

Graphs showing the relationship between age and elasticity/strength of connective tissue.

Graph (a): Elasticity (MPa) vs. Age (years)
- Trend line: $y = 142.1 - 140x$
- Correlation coefficient: $r = 0.712$
- Significance: $p < 0.05$

Graph (b): Strength (MPa) vs. Age (years)
- Trend line: $y = 55.82 - 0.821x$
- Correlation coefficient: $r = 0.863$
- Significance: $p < 0.05$
BODY COMPOSITION CURVES

- Body mass (kg) vs. Age (years) for Men and Women
- Fat free mass (kg) vs. Age (years) for Men and Women
- Percentage body fat vs. Age (years) for Men and Women
BONE DENSITY CURVES

The graph shows the relationship between bone mineral density (mg/cm²) and age (years) for men and women. The lines indicate a downward trend, suggesting a decrease in bone density with increasing age. The error bars represent the variability in bone density measurements.
BENDING THE AGING CURVE

Lifelong training
Bent aging curve
Untrained

Muscle area (mm²/48)

Age (years)
WHAT IS FRAILTY?

INDEPENDENCE

PHYSICAL VULNERABILITY

FRAILTY

DECLINING PHYSICAL RESERVE
FRAILTY AND PHYSICAL RESERVE

Maximum capacity
- Level required for task performance or maintenance

Stability
- Extensor power
  - 4.0 W/kg bw
- Power required to climb stairs
  - 2.0 W/kg bw

Vulnerability
- Extensor power
  - 2.2 W/kg bw
- Power required to climb stairs
  - 0.2 W/kg bw
THE DIAMOND ANALOGY

- Independence
- Strength
- Power
- Flexibility
- Balance
- Mobility
- Aerobic capacity
HOW DO WE TARGET THE SPECIFIC NEEDS OF THE INDIVIDUAL?

THE CLASSIC DIAGNOSIS/PRESCRIPTION
GENERAL VS. SPECIFIC DIAGNOSES
## Table 2.1  Sample Diagnostic Sheet

For Females, 65 to 69 Years Old  

<table>
<thead>
<tr>
<th>Test</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Average</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair Sit-and-Reach, Left (in.)</td>
<td>2.5</td>
<td>2.5</td>
<td>2.50</td>
<td>50-75</td>
</tr>
<tr>
<td>Chair Sit-and-Reach, Right (in.)</td>
<td>2</td>
<td>2.5</td>
<td>2.25</td>
<td>50-75</td>
</tr>
<tr>
<td>Back Scratch, Left (in.)</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>50-75</td>
</tr>
<tr>
<td>Back Scratch, Right (in.)</td>
<td>0</td>
<td>-1</td>
<td>-0.50</td>
<td>50-75</td>
</tr>
<tr>
<td>Modified Trunk Rotation (in.)</td>
<td>27</td>
<td>26</td>
<td>26.50</td>
<td>50-75</td>
</tr>
<tr>
<td>Single-Leg Stance Balance (s)</td>
<td>26</td>
<td>25</td>
<td>25.50</td>
<td>50-75</td>
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<tr>
<td>Functional Reach (in.)</td>
<td>15</td>
<td>15.2</td>
<td>15.10</td>
<td>50-75</td>
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<tr>
<td>8-Foot (2.4 m) Up-And-Go (s)</td>
<td>5.6</td>
<td>5.5</td>
<td>5.55</td>
<td>50-75</td>
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<tr>
<td>30-Second Chair Stand (reps)</td>
<td>14</td>
<td>14</td>
<td>14.00</td>
<td>50-75</td>
</tr>
<tr>
<td>Modified Ramp Power (s)</td>
<td>1</td>
<td>0.9</td>
<td>0.95</td>
<td>50-75</td>
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<tr>
<td>30-Second Arm Curl (reps)</td>
<td>16</td>
<td>17</td>
<td>16.50</td>
<td>50-75</td>
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<tr>
<td>Gallon Jug Shelf (s)</td>
<td>9</td>
<td>8.9</td>
<td>8.95</td>
<td>50-75</td>
</tr>
<tr>
<td>6-Minute Walk (yards)</td>
<td>600</td>
<td>600</td>
<td>600.00</td>
<td>50-75</td>
</tr>
<tr>
<td>15-Foot (4.6 m) Walk, Usual (s)</td>
<td>3.1</td>
<td>3.93</td>
<td>3.52</td>
<td>50-75</td>
</tr>
<tr>
<td>15-Foot (4.6 m) Walk, Maximal (s)</td>
<td>2.5</td>
<td>2.4</td>
<td>2.45</td>
<td>50-75</td>
</tr>
<tr>
<td>% Body Fat</td>
<td>28.3</td>
<td>28.3</td>
<td>28.3</td>
<td>50-75</td>
</tr>
</tbody>
</table>

BMI

| Modified Ramp Power Test                  |         |         |         |            |
| Ramp Height (m)                           | 0.33     |         |         |            |
| Ramp Power (absolute)                     | 224.73   |         |         |            |
| Ramp Power (per kg bw)                    | 3.41     |         |         |            |

Skinfolds

<table>
<thead>
<tr>
<th>Test</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Midaxillary</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>Suprailliac</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Abdominal</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Thigh</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Triceps</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Subscapular</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Sum</td>
<td>136.0</td>
<td>136.0</td>
</tr>
<tr>
<td>Body Density</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>% Body Fat</td>
<td>28.3</td>
<td>28.3</td>
</tr>
</tbody>
</table>

Note: The Test column shows the name of the test and the units you should use when entering each trial’s result.
ELEMENTS OF AN EFFECTIVE TEST

Element #1
ADL / IADL Specific Test

Element #2
Test for Impact on Daily Living

Element #3
Controlling Physiological Factor
THE EVOLVING PATIENT

EXERCISE ACTIVITY

CONFLICTING ENVIRONMENTS

AGE MALADIES INACTIVITY
TRAINING:
The Prescription
BIOENERGETIC SPECIFICITY:

- Enzyme structure, concentration and distribution
- Organelle structure, concentration and distribution
- Fiber type changes
- Electrochemical changes
- Hypertrophy and Hyperplasia
- Hormones

BIOMECHANICAL SPECIFICITY:

- Specific muscles and muscle groups
- Specific joints
- Specific joint angles and related muscle lengths
- Specific movement speeds
- Specific loads
- Specific contractile states
- Specific motor patterns
1. Rotation of the foot sends force and velocity to the lower leg.

2. Rotation is transferred to the thigh and force and velocity increased by large hip and knee extension.

3. Rotation of the hip further increases force and velocity due to its horizontal width.

4. Core muscles rotate shoulders to further increase force and velocity.

5. Addition of the long bones of the arms and wrist complete the movement.

1. Rotation of the foot sends force and velocity to the lower leg.
BODY COMPOSITION
IMPLICATIONS

Cardiovascular Disease

Independence
TESTING BODY COMPOSITION

- Dual energy x-ray densitometry (DEXA)
- Hydrostatic (underwater) weighing
- Air displacement plethysmography
- Bioimpedance
- Near-infrared spectroscopy
- Skinfold thickness and anthropometric measures
- Waist-to-Hip Ratio
- BMI
TRAINING INTERVENTIONS FOR SARCOPENIC OBESITY

- aerobic exercise without dieting has limited weight loss potential and little or no effect on lean body mass,
- resistance exercise has little effect on weight loss but can increase FFM,
- weight loss due to dietary changes alone results in a loss of 25% to 30% of overall body mass,
- combining diet and exercise can increase weight loss, and
- an exercise protocol that includes resistance training helps to maintain lean body mass and performance.
Resistance Training
Benefits of Resistance Training

The first thing you should know is that resistance training causes an increase in resting metabolic rate (RMR) in your older clients similar to what you see in younger persons and the increase in RMR is usually accompanied by an increase in FFM. Additionally, resistance training can also produce a significant increase in 24-h energy expenditure and fat utilization.
Most Effective Methods of Resistance Training

You can control a number of factors when designing a resistance training program for your client. They include: resistance level, number of sets and sessions per week, equipment used, training patterns, and movement speed.
Most Effective Methods of Resistance Training

High-speed explosive training using 60%1RM can burn more calories than the low-speed or 80%1RM high-speed explosive conditions and effectively improve ADL performance and reduce fall probability in persons with sarcopenic obesity; therefore, high-speed, moderate-resistance training cycles appear to be the “two-for-one” special on your training menu.
Aerobic Training
Figure 4.16  Changes in total-body fat mass and trunk fat mass due to high-intensity interval training and steady-state training over a 15-week period.
* Indicates greater decreases than the steady state and control groups.
Data from Trapp 2008.
Both steady state and interval training can be used at various times throughout a training cycle to make the best use of their inherent differences in volume and intensity; however, each method has its own specific strengths and shortcomings when considering a person’s metabolic and body composition-based needs.
Mixed Training
Application Point: Although data suggest there is an interference effect when mixing cardiovascular endurance and resistance training, combined training is an effective strategy when considering changes in body composition, especially when you understand how to modify the training protocols.
FLEXIBILITY
Types of Flexibility

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>static flexibility</td>
<td>The ability to slowly move a specific joint or series of joints to the end range of motions and maintain that position without moving.</td>
</tr>
<tr>
<td>dynamic flexibility</td>
<td>The ability to actively move through the full range of motion of a joint or series of joints at a specific movement speed, transitioning through each position.</td>
</tr>
</tbody>
</table>

**APPLICATION POINT**

Interventions to increase flexibility help older adults to maintain their ability to perform ADLs and to reduce their probability of falling.

*Figure 5.1* The strain–stress curve for flexibility.
Flexibility Testing

Figure 5.4  The chair sit-and-reach test evaluates flexibility in the low back and hamstrings.

Figure 5.5  The back scratch test assesses shoulder flexibility.

Figure 5.6  The modified trunk rotation test assesses core ROM.

Figure 5.7  Testing for plantar flexion and dorsiflexion.
Types of Stretching

• Static
• Ballistic
• PNF
APPLICATION POINT Flexibility training alone, without the addition of any other training modalities, can improve ROM and reduce passive resistance.

APPLICATION POINT Flexibility can be improved even by programs that combine flexibility training with other training modalities; however, mixed programs may be less effective than programs concentrating solely on flexibility.

APPLICATION POINT Regular flexibility training rather than acute stretching leads to long-term changes, including structural changes in muscle and connective tissue, that can protect against injury.

APPLICATION POINT For older persons, flexibility training can improve every aspect of performance, from gait to ADL performance.
BONE DENSITY AND BALANCE
Bone Structure

Figure 6.1 Illustration of two major types of bone: cortical and trabecular.

Figure 6.2 Detailed microscopic view of the lamellae in the Haversian system in cortical bone.

Figure 6.3 Microscopic view of trabecular (spongy) bone.
Figure 6.4  Changes in bone growth and bone loss in women from infancy to old age. Notice the rapid bone loss between the ages of 50 and 60 years, when menopause is most prevalent.
Bone Geometry and Training

Normal bone matrix
A standard roof truss is analogous to normal, healthy trabecular bone.

Osteoporosis
The roof truss with structural bracing missing is analogous to osteoporotic bone. Note the reduction in the size and number of bridges (trabeculae) and the increase in resorption cavities (spaces), both of which reduce bone strength.

Trained bone matrix
The roof truss with added bracing for greater strength is analogous to trained bone. Notice the increase in trabeculae and the decrease in resorption cavities.

Figure 6.7 Of roof trusses and bone: a comparison of normal, osteoporotic, and trained bone matrix.
Osteopenia and Osteoporosis

Figure 6.8 A bell-shaped curve showing the standard distribution of bone densities of healthy young adults. Individuals who have osteopenia have bone densities that are 1 to 2.5 standard deviations below the mean, while people with osteoporosis have bone densities that fall at least 2.5 standard deviations below the mean.
Dual Emission X-ray Analysis (DEXA)
1. Bone adapts best to dynamic rather than static mechanical stimulation.
2. If a bone is to respond to training, the stimulus must be at a suprathreshold level.
3. The response that any bone has to a mechanical stimulus such as exercise is proportional to the loading cycle, which is how frequently the stimulus is applied.
4. The response of bone to exercise is improved by brief but intermittent exercise.
5. Bone responds best when the exercise employs a pattern that differs from the usual loading pattern.
6. For bone to adapt, it must have sufficient energy to rebuild itself.
7. For exercise to work there should be abundant calcium and vitamin D availability.
Better Balance and Agility

Figure 6.11  Age-adjusted fatal fall injury rates among men and women aged 65 years and older in the United States between 1994 and 2003.
Reprinted from CDC.
CENTER OF GRAVITY

MAXIMAL EXCURSION OF
CENTER OF GRAVITY
WITHIN THE BASE OF
SUPPORT

BASE OF SUPPORT

CENTER OF GRAVITY

OUTSIDE BASE OF
SUPPORT CAUSES
LOSS OF EQUILIBRIUM
OBJECT FALLS
THE TESTS
THE PRESCRIPTION

TARGETED
• Tai Chi
• Balance and Agility Training Programs
• Balance Platforms
• Whole Body Vibration
• Activity Promoting Video Games

SUPPORT
• Lower Body Power Training
• Speed Training
• Flexibility Training
MUSCULAR STRENGTH AND POWER
SARCOPENIA

Lower that approximately 97.6% of the population
Neuromuscular Causes

1. Shrinking cross-sectional areas of all muscle fibers (muscle cells). This is specially true for the type II fast-twitch fibers.
2. Fewer motor nerves and an increase in the size of the remaining motor units.
3. Structural changes in the neuromuscular junction.
4. Reduced calcium flow inside the muscle, which leads to slower, less powerful contractions.
5. Less satellite cell activity.

Biochemical Causes

1. Reduced levels of anabolic hormones (growth hormone (GH), insulin-like growth factor (IGF), and testosterone.
2. Reduce energy production (especially for protein synthesis).
Neuromuscular Causes

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Biochemical Causes

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2. Reduced energy production (especially for protein synthesis).
THE TESTS

1. 30-second arm curl
2. 30-second chair rise
3. Gallon jug shelf test
4. Ramp Power Test
TRAINING CONSIDERATIONS

• GOAL
• CURRENT TRAINING STATUS
• WORK AND RECOVERY

BASIC QUESTIONS

• TRAINING LOAD
• NUMBER OF REPETITIONS
• NUMBER OF SETS
• SESSIONS PER WEEK
• MUSCLE GROUPS
• KINETIC CHAIN
A SPECIFIC EXAMPLE: POWER

Load where the force x velocity gives the highest power output.

Balance Gait speed
Chair rise Stair climb

Force
Fulcrum
Resistance

Long class three lever: Favors movement velocity

Short class two lever: Favors force production
CARDIOVASCULAR / METABOLIC TRAINING
CONCERNS

1. Reduced Aerobic Capacity
2. Central Obesity
3. Insulin Resistance
4. Lipid Profile
5. Blood Pressure
6. Heart Rate Variability
Figure 8.8  The 6-minute walk test.
### CONCERNS

<table>
<thead>
<tr>
<th></th>
<th>Reduced Aerobic Capacity</th>
<th>Central Obesity</th>
<th>Insulin Resistance</th>
<th>Lipid Profile</th>
<th>Blood Pressure</th>
<th>Heart Rate Variability</th>
</tr>
</thead>
</table>

Best addressed using steady state training

Best addressed using high intensity intervals
CONSIDER THE POSSIBILITIES

Figure 8.9 The types of exercise, equipment, and training protocols used for improving cardiovascular fitness.
PERIODIZATION:
Putting the Program Together
Figure 9.1 The phases of the supercompensation curve.
Supercompensation Curve

Single Factor: Fatigue Model

Two Factor: Fitness-Fatigue Model

TRAINING STIMULUS

Fitness Effect

Fatigue Effect

Fitness After-effect

Fatigue After-effect
To much overload causes overtraining.

To little overload insufficient to cause a training effect.

Proper overload provides optimal training effect.

To much overload causes overtraining.
The Nature of Various Cycles

Figure 9.6 (a) The classic linear training cycle illustrating a gradual increase in intensity and decrease in volume across the training period. (b) An undulating, or nonlinear, mesocycle. Note the fluctuations in intensity and volume and the reciprocating nature of this undulation, in which increases in intensity are associated with decreases in volume and vice versa.
# BLOCK CYCLING

<table>
<thead>
<tr>
<th>Accumulation</th>
<th>Restitution or Transmutation</th>
<th>Competition or Realization</th>
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<tr>
<td>Increases performance variables that prepare the body to maximize specific gains during a targeted cycle.</td>
<td>To increase the intensity and specificity of the exercise and improve goal-specific performance.</td>
<td>To practice goal specific drills designed to translate physiological gains into specific goals.</td>
</tr>
</tbody>
</table>

Residual Effects
Figure 10.2 Three-dimensional diagram of factors that should be considered when designing a translational cycle.
Figure 10.3  The three components (intensity, volume, and complexity) that can be manipulated during a translational cycle.
<table>
<thead>
<tr>
<th>Power, balance, and speed</th>
<th>Both</th>
<th>Strength, balance, and control</th>
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</thead>
<tbody>
<tr>
<td>Functional reach drill</td>
<td>Heel stand</td>
<td>Skating drill</td>
</tr>
<tr>
<td>Pillow stands</td>
<td>Heel walk</td>
<td>Lateral advances</td>
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<tr>
<td>Triple-line drill</td>
<td>Lateral throw</td>
<td>Back-to-back handoff</td>
</tr>
<tr>
<td>Lateral shuffle drill</td>
<td>Forward and backward passes</td>
<td>Chest pass</td>
</tr>
<tr>
<td>Forward and backward cone drill</td>
<td>Truckin’ drill</td>
<td>Overhead and lateral throw</td>
</tr>
<tr>
<td>Zigzag drill</td>
<td>Dual tasking</td>
<td>Soccer kicks</td>
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<tr>
<td>Cone-touch drill</td>
<td>8-foot (2.4 m) up-and-go drill</td>
<td>Broom hockey</td>
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<tr>
<td>Speed and stride drill</td>
<td>Ladder drills</td>
<td>Step drill</td>
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<tr>
<td>Hexagon drill</td>
<td>Chair drills</td>
<td>Scarf drill</td>
</tr>
<tr>
<td>Star excursion drill</td>
<td>Coin pickup drill</td>
<td>Book drills</td>
</tr>
<tr>
<td></td>
<td>Gallon jug drill</td>
<td>Ball-and-pylon drills</td>
</tr>
<tr>
<td></td>
<td>Dot drills</td>
<td>Floor coin pickup drill</td>
</tr>
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</table>
INCREASED CAPACITY

NEW PRESCRIPTION

DIAGNOSTIC TESTING

THE PATTERN

RESISTANCE TRAINING CYCLE

MOTOR LEARNING CYCLE

INCREASED CAPACITY
Questions?
Order your copy of *Bending the Aging Curve* at [HumanKinetics.com](http://www.HumanKinetics.com) before April 30, 2011 and save 30%.

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Mark your calendar for 12:00 Eastern (11:00 Central) Thursday, May 5th. The next installment in the series, *Fascial Stretch Therapy (FST): The missing link in training, fitness, and rehab* will feature Chris Frederick, author of *Stretch to Win*.