CARDIOVASCULAR SYSTEM AND THE BRAIN
CARDOVASCULAR SYSTEM AND THE BRAIN

Consists of a pump and more than 60,000 miles of blood vessels.

Fun Fact: Circumference of the Earth is 25,000 miles.
CARDIOVASCULAR SYSTEM AND THE BRAIN

Shuttles oxygenated and deoxygenated blood

Removes waste by-products for reuse or elimination

Transports enzymes and hormones to regulate function

Distributes nutrients to the cells

Maintains body temperature

Regulates pH to control acidosis and alkalosis
Definition of Cardiovascular activity

Activities that cause an increase in distribution and uptake of oxygen by skeletal muscles. Performed repeatedly over time provides numerous health benefits.
One of the Major determinates in tolerance to all exercise and activity with aging is cardiovascular function. More we improve function the easier life feels and becomes.

Exercise over time results in better conditioned heart. Does more with each heartbeat (nutrients, oxygen)
CARDBIOVASCULAR SYSTEM AND THE BRAIN

Walking at Disney World with grandkids

40% vs 90% maximal effort

Those who are aerobically fit have less incidence of chronic illnesses – High BP, Stroke, Heart Disease, Diabetes and some Cancers.

[5, 6, 7, 8, 9, 10]
Exercises for Health vs Fitness

Activity that would only yield small fitness improvement had significant health benefits. Benefits are dose related, the more volume of activity the greater the benefits.
CARDIOVASCULAR SYSTEM AND THE BRAIN

Just a few Benefits...

Decreased fatigue in everyday activities
Improved immune function
Improved glucose tolerance and insulin sensitivity
Improved body composition
CARDDIOVASCULAR SYSTEM AND THE BRAIN

**Ok just a few more..**

<table>
<thead>
<tr>
<th>Improved Cardiorespiratory Function</th>
<th>Reduced Risk of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCREASED MAXIMAL OXYGEN UPTAKE</strong></td>
<td><strong>MORTALITY FROM ALL CAUSES</strong></td>
</tr>
<tr>
<td><strong>INCREASED MAXIMAL CARDIAC OUTPUT AND STROKE VOLUME</strong></td>
<td><strong>CORONARY ARTERY DISEASE</strong></td>
</tr>
<tr>
<td><strong>INCREASED CAPILLARY DENSITY IN SKELETAL MUSCLE</strong></td>
<td><strong>CANCER (COLON, AND POSSIBLY BREAST AND PROSTATE)</strong></td>
</tr>
<tr>
<td><strong>INCREASED MITOCHONDRIAL DENSITY</strong></td>
<td><strong>HYPERTENSION</strong></td>
</tr>
<tr>
<td><strong>INCREASED LACTATE THRESHOLD</strong></td>
<td><strong>NON-INSULIN DEPENDENT DIABETES</strong></td>
</tr>
<tr>
<td><strong>LOWER HEART RATE AND BLOOD PRESSURE AT SUBMAXIMAL RATE</strong></td>
<td><strong>OSTEOPOROSIS</strong></td>
</tr>
<tr>
<td><strong>LOWER HEART OXYGEN DEMAND AT SUBMAXIMAL RATE</strong></td>
<td><strong>ANXIETY AND DEPRESSION</strong></td>
</tr>
</tbody>
</table>
CARDIOVASCULAR SYSTEM AND THE BRAIN

GAINS AT ANY AGE

Magnitude of gains similar, even greater than younger adults

12 week study of untrained men 60-70yrs vs 20-30yrs vigorous cycling ergometer

Older adult group 38% increase in VO2, younger group 29%

Other studies have demonstrated same ability of older adults
CARDIOVASCULAR SYSTEM AND THE BRAIN

Beauty of Aerobic Exercise is All The Choices

Arthritis - water classes, swimming, cycling, UBE

Short bouts of 10min can be a

Sports and hobbies like gardening...
### Functional Fitness Standards for Older Adults

<table>
<thead>
<tr>
<th>Test</th>
<th>60-64</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>80-84</th>
<th>85-89</th>
<th>90-94</th>
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</thead>
<tbody>
<tr>
<td>Chair stand (# in 30 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Men</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Arm curl (# in 30 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Women</td>
<td>17</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Men</td>
<td>19</td>
<td>18</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>6-minute walk (# of yd)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Women</td>
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<td>580</td>
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<td>510</td>
<td>460</td>
<td>400</td>
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<tr>
<td>Men</td>
<td>680</td>
<td>650</td>
<td>620</td>
<td>580</td>
<td>530</td>
<td>470</td>
<td>400</td>
</tr>
<tr>
<td>2-minute step (# of steps)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>97</td>
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<td>89</td>
<td>84</td>
<td>78</td>
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<tr>
<td>Men</td>
<td>106</td>
<td>101</td>
<td>95</td>
<td>88</td>
<td>80</td>
<td>71</td>
<td>60</td>
</tr>
<tr>
<td>8-foot up-and-go (sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>5.0</td>
<td>5.3</td>
<td>5.6</td>
<td>6.0</td>
<td>6.5</td>
<td>7.1</td>
<td>8.0</td>
</tr>
<tr>
<td>Men</td>
<td>4.8</td>
<td>5.1</td>
<td>5.5</td>
<td>5.9</td>
<td>6.4</td>
<td>7.1</td>
<td>8.0</td>
</tr>
</tbody>
</table>

The functional fitness standards for each age group are the fitness scores needed to maintain functional mobility and physical fitness until late in life despite normal age-related declines, as described in previously published research (Rikli & Jones, 2012).
How to determine exercise intensity needed

**CARDIOVASCULAR SYSTEM AND THE BRAIN**

**How to determine exercise intensity needed**

**Old method still ok for younger adults:** 220 - age

**More accurate especially for older adults:** 208 - (age x .7)

<table>
<thead>
<tr>
<th>Age</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>178</td>
<td>179</td>
</tr>
<tr>
<td>85</td>
<td>135</td>
<td>149</td>
</tr>
</tbody>
</table>
CARDIOVASCULAR SYSTEM AND THE BRAIN GUIDELINES

65-90% max HR
55-64% max HR for beginners is acceptable

Quick way to take pulse: radial or carotid
10s x 15s x 20s x 30s x
6 4 3 2

Impact of some medications
CARDIOVASCULAR SYSTEM AND THE BRAIN

Don’t have to overcomplicate it

If you don’t have heart rate monitor use RPE or Talk Test. Rating of Perceived Exertion. Modified Borg Scale of Exertion 0-10 Scale. Moderate is 5-6, Vigorous is 7-8 (85% max HR)

Talk Test

Light- You can carry on a conversation

Moderate- You can say a few sentences at a time

Vigorous- You can talk but you don’t feel like it

Very Heavy- Can answer “yes” or “no” not much beyond on that
CARDIOVASCULAR SYSTEM AND THE BRAIN
Guidelines

**Moderate intensity:** 30min most days of week can be accumulated in 10min bouts

**Vigorous intensity:** 20min continuous most days of week

**Warm up and Cool down 5-15min each**
HIIT (High Intensity Interval Training)

Short bouts of more intense activity followed by recovery periods

Intensity picked up relative to the individual’s max HR

Examples: 3 min faster walking followed by 3 min slower recovery

30 second “sprints or pick ups” followed by 4 min recovery

Repeated 3-5 times

A foundation of basic conditioning before implementing
HIIT (High Intensity Interval Training)

Physiological benefits with less exercise time

Study of 1 min vigorous (90% Max HR) for 10 bouts with 1 min rest periods

Average age 65yrs, obese with Type 2 diabetes (free of complications)
Just two weeks of training 30min each week (vs 75min guidelines)
HIIT was effective in reducing 24hr mean blood glucose levels

[16]
HIIT (High Intensity Interval Training) Compared to 30min of continuous exercise at 65% max HR

Both protocols improve body fat mass, cardio fitness, fasting blood glucose and endothelial function (lining of arteries).

HIIT protocol of 6 x 1min bouts of 85% max HR with 4min recovery

Study of 12 weeks with 43 type 2 diabetics ages 50-70yrs on blood glucose lowering medication but not on insulin

HIIT protocol of 6 x 1min bouts of 85% max HR with 4min recovery compared to 30min of continuous exercise at 65% max HR

Both protocols improve body fat mass, cardio fitness, fasting blood glucose and endothelial function (lining of arteries) but

HIIT Training -> greater improvements & only one to impact A1C
HIIT (High Intensity Interval Training)

Meta Analysis of 10 studies of 273 patients

Had Coronary Heart Disease, Heart Failure, Hypertension, Metabolic Syndrome and Obesity

HIIT Training significantly increased Cardiorespiratory Fitness (VO2 max) compared to Moderate Intensity Continuous Training

HIIT Almost Doubled improvement compared to Moderate Continuous!
HIIT (High Intensity Interval Training)

HIIT Safety

ADA recommends 12 lead ECG test for those with Type 2 Diabetes before engaging in vigorous activity [14]

Seven year analysis of over 5,000 patients of supervised cardiac rehabilitation exercise reported low risk of HIIT [15]

One nonfatal heart attack per 23,182 hours of HIIT training [15]

Physician clearance for Diabetic and Heart conditions
CARDIOVASCULAR SYSTEM AND THE BRAIN

Massive benefits to the body, highly modifiable, can be accumulated

Mountains of research, easier for rodents to do cardio

While massive benefit to the exciting it’s impact on the brain
Exercise and the Brain
Exercise and the Brain

Where did all this attention between exercise and the brain come from?

BDNF (Brain-Derived Neurotrophic Factor)

Nourishes neurons, helps build and maintain the cells' infrastructure.

Improves signal strength between synapses.

Improves function and encourages growth of neurons.

Also strengthens and protects from natural cell death.

Introduced to neurons in petri dish helps survive and grow dendrites.
Exercise and the Brain

From Older Adults to The “Midnight Mice Marathon” Study

Divided into 4 groups: running for 2, 4 or 7 nights

One control group without treadmill
Exercise and the Brain

The “Midnight Mice Marathon” Study

Injected with molecule that binds to BDNF and scanned
The running mice had increased BDNF levels. The more they ran the higher the levels.
Thought changes would occur in motor sensory areas of the brain dealing with movement

But
Exercise and the Brain

Showed in hippocampus—which is vulnerable to degenerative disease and needed for learning and memory.

Demonstrated link between movement and cognitive function.

It derives its name from its resemblance with a seahorse (< Greek 'hippos' meaning horse and 'kampos' meaning sea monster).
Exercise and the Brain

Other studies solidified the connection between neurons and learning. LTP (Long Term Potentiation) is a method of strengthening the connection between neurons. Inversely, mice without BDNF lose the ability to learn. Found that if LTP was stimulated in mice by making them learn, BDNF levels rose. Finally, injecting BDNF directly into the brain of rats encouraged LTP.
Exercise increases levels of BDNF (Miracle Gro) in the hippocampus.

Higher levels of BDNF are associated with better memory function and larger hippocampal volumes.

BDNF is a player in neurogenesis and also contributes to the branch-like dendrites expanding.
CARDIOVASCULAR SYSTEM AND
THE BRAIN

With Exercise also the RATE of learning improves.

2007 German study of humans

Found that people learned vocabulary words 20% faster following exercise than they did before.
Rate of learning directly tied to levels of BDNF.
CARDIOVASCULAR SYSTEM AND THE BRAIN

Exercise directly influences the Brain

The Brain is adaptable or "plastic" as muscles are able to be "sculpted"

The Brain is less hardwired and more constantly being rewired
CARDIOVASCULAR SYSTEM AND THE BRAIN

Even has the ability in certain sections to make new neurons

Terminally ill cancer patients injected with dye showed neurogenesis in hippocampus.

Doesn’t happen in all areas.

In 2006 study improved fitness participants had increase in brain volume in frontal and temporal lobes.
CARDIOVASCULAR SYSTEM AND THE BRAIN

New Neurons must be put to use or they die

Born with blank slate

Must integrate and fire its axon survive

Exercise births the neurons but the environmental enrichment helps them survive.
CARDIOVASCULAR SYSTEM AND THE BRAIN

With age our brains degrade and even shrink [31]

Gray matter volume decreases by approximately 15%, from the 20s through the 70s [33]

Exercise can help regain in certain areas that volume

Can occur from new neurons, greater dendrite branching or complexity, or new capillaries formed. [34,35, 36]
CARDIOVASCULAR SYSTEM AND THE BRAIN

One Year Randomized controlled study of 120 older adults without dementia

Group one 60 adults did aerobic exercise
Group two 60 adults just did stretching

MRI done beginning, 6 month point, end of one year
(no hippocampus difference in groups at beginning)
CARDIOVASCULAR SYSTEM AND THE BRAIN

At end of one year:

Stretching control group LOST left and right volume 1.40% and 1.43%

Aerobic exercise group increased volume of left and right hippocampus 2.12% and 1.97%
Aerobic exercise group increased volume of anterior hippocampus by 2%

Anterior portion shows more age related decline than tail of hippocampus

Hippocampus volume shrinks 1-2% per year in older adults without dementia, increasing risk of impairment

[22,23,24,25]
Cardiovascular System and The Brain

Authors stated:

“These results clearly indicate that aerobic exercise is neuroprotective and that starting an exercise regimen later in life is not futile for either enhancing cognition or augmenting brain volume.”
CARDIOVASCULAR SYSTEM AND THE BRAIN

AEROBIC ACTIVITY SPECIFICS FOR STUDY:

WALKED 3 DAYS PER WEEK

WEEKS 1-7 DID 50-60% MAX HR, AFTER THAT 60-75% REMAINDER
WEEK 1 STARTED WITH WALKING 10MIN

EACH WEEK ADDED 5MIN UNTIL AT 40MIN BY WEEK 7. STAYED AT 40MIN FOR REMAINDER
Importance of Socializing and Play

Berkley Study Environmental Enrichment

Rats Sensory and Social Stimuli learned better than those in isolation

Also their brains weighed more

Study led to development of Federal Head Start Program for preschool
CARDIOVASCULAR SYSTEM AND THE BRAIN

Importance of Socializing and Play

How about a human study

Rush Alzheimer's Disease Center

Those who reported feeling lonely were 2x likely to develop Alzheimer's
CARDIOVASCULAR SYSTEM AND THE BRAIN

Wrapping up.

Research indicates age-related cognitive decline due more to secondary effects of lifestyle specifically health and fitness than primary aging.

Programs that incorporate cognitive challenges with aerobic exercise lead to larger improvements.
Exercise also...

Balances neurotransmitters like dopamine, serotonin and norepinephrine

Reduces risk of obesity. Being overweight doubles chance of dementia

With high blood pressure and cholesterol it’s 6 x risk
CARDIOVASCULAR SYSTEM AND THE BRAIN

For Brain Health...

Do Aerobic activity most days of the week but at least aim for 4 days. 30min – 1hr

Aim for 60-65% Max HR, two days bump up to 70-75%

Try to do outside and with a friend. (Environment, Social and Cognitive)

Seek Novel experiences, break the rut
REFERENCES


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[29] The NY Times., OCT. 30, 1998 ADULT BRAIN CELLS SAID TO REPRODUCE., by Holcomb B. Noble


