26 miles 385 yards = 42195 meters
Malosky Stadium, 1 lap = 400 meters
105.49 laps in 7418 seconds or
70.32 seconds per lap = 100 meters in 17.58 seconds
12.72 mph
Estimated VO₂ = 72 ml/kg/min or 20.5 METS
assuming normal human efficiency

Your predicted VO₂ at _ kg resistance, 50 rpm =
1 = 3 METS  6 = 14.5
2 = 5.5 METS  7 = 16.5
3 = 7 METS  8 = 18.5
4 = 10.5 METS  9 = 20.5
5 = 12.5 METS

The metabolic equivalent (MET)

• Useful method of normalizing VO₂ and energy expenditure across individuals.

• 1 MET approximates the rate of energy expenditure at rest

• Because the MET normalizes across subjects, exercise intensity is often prescribed in METs

1 MET = 3.5 ml O₂/kg/min or approximately 1 kcal/kg/hour

55 kg female:

Resting energy expenditure ~ 55 kcal/hour or 1320 kcal/day

Exercise at 4 METs for 60 minutes
Energy expended ~ 240 kcal/hour
## Standards for VO₂ max based on Treadmill Testing

### FEMALE

<table>
<thead>
<tr>
<th>Age</th>
<th>Very Poor</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
<th>Superior</th>
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<tbody>
<tr>
<td></td>
<td>m/l/min</td>
<td>m/l/min</td>
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<tr>
<td>17-19</td>
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<td>69</td>
<td>80</td>
<td>93</td>
<td>105</td>
<td>120</td>
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<tr>
<td>20-29</td>
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<td>65</td>
<td>76</td>
<td>88</td>
<td>101</td>
<td>115</td>
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<tr>
<td>30-39</td>
<td>46</td>
<td>62</td>
<td>73</td>
<td>84</td>
<td>97</td>
<td>111</td>
</tr>
<tr>
<td>40-49</td>
<td>43</td>
<td>59</td>
<td>70</td>
<td>80</td>
<td>93</td>
<td>107</td>
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<tr>
<td>50-59</td>
<td>41</td>
<td>56</td>
<td>66</td>
<td>76</td>
<td>88</td>
<td>102</td>
</tr>
<tr>
<td>60+</td>
<td>39</td>
<td>53</td>
<td>63</td>
<td>73</td>
<td>85</td>
<td>99</td>
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### MALE

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<td>120</td>
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<td>20-29</td>
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<td>76 80</td>
<td>93 97</td>
<td>105 111</td>
<td>120 125</td>
<td>135 150</td>
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<td>73 78</td>
<td>84 90</td>
<td>97 102</td>
<td>111 116</td>
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<td>66 71</td>
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<td>61 66</td>
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<td>83 88</td>
<td>97 102</td>
</tr>
<tr>
<td>60+</td>
<td>38 43</td>
<td>50 55</td>
<td>60 65</td>
<td>70 75</td>
<td>82 87</td>
<td>96 101</td>
</tr>
</tbody>
</table>

### Graphs

- **Graph 1:** Oxygen uptake vs. time (seconds) for different age groups.
- **Graph 2:** Power output vs. kg resistance for different age groups.
Oxygen Uptake = amount of O₂ used to support ATP production per unit time

\[ \text{VO}_2 = \text{blood flow (ml/min)} \times \text{oxygen extraction (ml/dl)} \]

\[ \text{VO}_2 = \text{HR} \times \text{SV} \times \text{arterial O₂ content} - \text{venous O₂} \]

- Maintain stable blood gasses
  - Increase Tidal Volume, Frequency, alveolar ventilation
  - Increase diffusion capacity O₂
  - Remove CO₂
    - Mitochondrial CO₂ production
    - Buffer H⁺
      - Produce CO₂ in bicarbonate reaction

- Reset regulation to allow
  - Increased Cardiac Output
  - Redistribute cardiac output
    - Active muscle vasodilation
    - Inactive muscle vasoconstriction
    - Renal, splanchnic vasoconstriction
    - Skin
      - Vasoconstriction
      - Vasodilation
    - Maintain venous return

- **ALL IN PROPORTION TO EXERCISE INTENSITY**
  - Major sympathetic activation
Mohrman's Rules

1. most everything you can measure increases with exercise
2. if it doesn’t increase, it remains constant or decreases

TPR decreases as active muscle dilated
Diastolic Pressure remains constant
End Systolic Volume decreases to increase stroke volume
Blood flow to gut and kidney decreases
Insulin Decreases
• Activity changes you at the cellular level
  – Acutely
  – Chronically

• Inactivity changes you at the cellular level
  – Acutely
  – Chronically

...we used gene arrays to determine the effects of 24-h HLS on metabolic remodeling in mouse muscle. Acute unloading resulted in differential expression of a number of transcripts in soleus and gastrocnemius muscle, including many involved in lipid and glucose metabolism.
Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity

Lionel Bey and Marc T Hamilton

1. inactivity significantly decreases muscle LPL activity
2. Inactivity caused a local reduction of plasma triglyceride uptake into muscle and a decrease in high density lipoprotein cholesterol concentration

Sustained muscle contraction

Physical Fitness
  Aerobic Fitness ↑
  Muscular Strength

Positive Changes in
  Skeletal muscle structure, function, and metabolism

Body fat ↓
  Visceral Fat]
  Liver Fat +

Heart Structure ↑
  Heart Function

Parasympathetic Tone

Peripheral Resistance ↑

Insulin +
  Sensitivity

Blood ↓
  Pressure

Electrical Stability of the Heart ↑

HDL Cholesterol

Risk of Ischemic Stroke ↓
  Platelet Aggregation

Risk of Type II Diabetes +
  Atherosclerosis

Risk of Myocardial Infarction +
  Risk of Death

Risk of Disability, Dementia

Neurotrophic Effects

Risk of Life ↓
  Threatening Arrythmia

Inflammation

Glycemic Control in Insulin Resistance

Risk of Death
What This?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Relative Risk Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td></td>
</tr>
<tr>
<td>Alzheimer</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
</tr>
<tr>
<td>Lung Cancer</td>
<td></td>
</tr>
<tr>
<td>Colon Cancer</td>
<td></td>
</tr>
<tr>
<td>Breast Cancer</td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td></td>
</tr>
<tr>
<td>Heart Failure</td>
<td></td>
</tr>
<tr>
<td>CAD (MI)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
</tr>
<tr>
<td>Risk Factors</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Main evidence-based pathways on how physical activity or exercise therapy delays progression of diseases and occurrence of disability and deaths.
Conclusions
The most consistent finding of the review studies summarised here is that aerobic/functional capacity and muscle strength can be improved by exercise training among patients with different diseases without having detrimental effects on disease progression. This is important, as with population aging exercise therapy may be an important means of reducing disability and increasing the number of older people living independently. Severe complications during these carefully tailored programs were rare. In some diseases, such as osteoarthritis, pain symptoms may also be reduced. As this review shows, there is accumulating evidence that in patients with chronic disease exercise therapy is effective in improving the prognostic risk factor profile.
An Obligation for Primary Care Physicians to Prescribe Physical Activity to Sedentary Patients to Reduce the Risk of Chronic Health Conditions

Mangi V. Chakravarthy, MD, PhD; Michael J. Joyner, MD; and Frank W. Booth, PhD

Physical inactivity increases the risk of many chronic disorders. Numerous studies have convincingly demonstrated that undertaking and maintaining moderate levels of physical activity (e.g., brisk walking 3 hours a week) greatly reduces the incidence of developing many chronic health conditions, most notably type 2 diabetes mellitus, obesity, cardiovascular disease, and many types of cancers. However, the underlying mechanistic details of how physical activity confers such protective effects are not well understood and consequently constitute an active area of research. Although changing an individual’s ingrained behavior is commonly perceived to be difficult, encouraging evidence suggests that intensive and repeated counseling by health care professionals can cause patients to become more physically active. Therefore, counseling patients to undertake physical activity to prevent chronic health conditions becomes a primary prevention modality. This article summarizes the vast epidemiologic and biochemical evidence supporting the many beneficial health implications of undertaking moderate physical activity and provides a rationale for incorporating physical activity counseling as part of routine practice in the primary care setting.


BMI = body mass index; CDC = Centers for Disease Control and Prevention; CHC = chronic health condition
How Much and What Type of Physical Activity Is Enough? What Physicians Should Tell Their Patients


...it is important for practitioners and their patients to not judge the health benefits of regular physical activity solely by its effect on conventional risk factors; they should counsel their patients that regular activity is beneficial whether or not it improves their lipid profile, blood pressure, weight, or glucose tolerance.
Exercise is Medicine

"If we had a pill that contained all of the benefits of exercise, it would be the most widely prescribed drug in the world,"

Ronald M. Davis,
M.D., AMA Past President.
Low level of cardio respiratory fitness (CRF) exposes a patient to a greater risk of dying than does smoking, obesity, hypertension, or high cholesterol.

1. CRF significantly increases length of life
2. Life expectancy of a moderately fit person in their 80's is as long as an unfit person in their 60's!
Increased physical activity coupled with avoidance of sedentary behavior

- Studies have identified unique health consequences of “too much sitting” that are distinct from those of “too little exercise.”

<table>
<thead>
<tr>
<th>Recommended exercise</th>
<th>Sitting opportunities (potential chair time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 AM</td>
<td>Drive to work 45 min—4 hours</td>
</tr>
<tr>
<td></td>
<td>Work on computer 45 min—4 hours</td>
</tr>
<tr>
<td></td>
<td>Eat lunch 45 min—4 hours</td>
</tr>
<tr>
<td></td>
<td>Work on computer 45 min—4 hours</td>
</tr>
<tr>
<td></td>
<td>Drive home 45 min—1 hour</td>
</tr>
<tr>
<td></td>
<td>Eat dinner 45 min—1 hour</td>
</tr>
<tr>
<td></td>
<td>Watch TV/Read 45 min—4 hours</td>
</tr>
<tr>
<td>1 PM</td>
<td></td>
</tr>
</tbody>
</table>

- the striking sensitivity of muscle LPL to inactivity and low-intensity contractile activity may provide one piece of the puzzle for why inactivity is a risk factor for metabolic diseases and why even non-vigorous activity provides marked protection against disorders involving poor lipid metabolism.
When a patient comes to a clinic
– check weight, calculate BMI
– measure blood pressure
– **measure physical activity**

- Evidence is now overwhelming on the health burden of physical inactivity.
- The benefits of exercise in the treatment and prevention of chronic disease cannot be denied.
- Physicians cannot continue to ignore this evidence when formulating treatment plans for our patients.
- **No patient should leave a doctor’s office without an assessment of his/her physical activity and proper prescription of an exercise program, or a referral to a certified fitness professional.**
What are the alternatives to activity

- The Puget Sound ferries in Washington have increased the width of their seats from 18 to 20 inches to allow squeeze-in room for people with bigger bottoms.

- In Colorado an ambulance company has retrofitted its vehicles with a winch and a plus-size compartment to handle patients weighing up to half a ton.

- An Indiana manufacturer of caskets now offers a “doublewide” model: 38 inches (96.5 centimeters) wide, compared with a standard 24 inches (61 centimeters).
EXERCISE is MEDICINE

- Exercise is the best "medicine" or "prescription" around
- Assess physical activity in ALL patients – record physical activity as a vital sign
  - how many minutes were you active
  - how hard were you breathing
- Only RARE patients need GXT before exercise
  - pts who are symptomatic CV/pulmonary
- The Prescription is: Be "FITT"
  - Frequency: 5 days a week (or more)
  - Intensity: moderate intensity, 5-6 on 10 scale
  - Time: 30 minutes aerobics (10-min chunks OK)
  - Type:
    - Aerobic activity
    - Muscular strengthening activity
    - Flexibility activity
    - Balance training

The prescription is EXERCISE

- moderate physical activity
  - performed at 3-6 times the basal metabolic
  - 3-6 METS: equivalent of brisk walking at 3-4 mph for 30 minutes each day in most healthy adults is protective against many Chronic Health (lowering) Conditions.
How Much Exercise is Required?

- 700 kcals per day minimum for weight loss
- 1000 kcals a week for health related benefits
- More is better up to a point
- Any activity is better than no activity
Every calorie makes a difference, whether eaten or spent

1 soda cracker extra per day = 10 kcals per day
350 days = 3500 kcals/year
1 lb per year
10 lbs per decade
60 lbs extra between age 20 and 80

- At 1 MET, you spend 1 kcal per kg per hours
  70 kcals/hr if weigh 70kg
- At 2.5 METS you spend 175 kcals/hr or 2.9 per minute, so it will take 3.5 minutes to burn 10 kcal

<table>
<thead>
<tr>
<th>MET</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>Walking, 2.0 mph, level, slow pace, firm surface</td>
</tr>
<tr>
<td>2.5</td>
<td>Walk from house to car or bus, from car or bus to go places, from car or bus to and from worksite, to neighbor's or family's house</td>
</tr>
<tr>
<td>2.5</td>
<td>Walking to and from outhouse</td>
</tr>
</tbody>
</table>