Physical Activity and Coronary calcification

ADJ ASSOCIATE PROFESSOR TAN SWEE YAW
NATIONAL HEART CENTRE SINGAPORE
Calcium Scores (CACS)
Calcium Scores (CACS)

- Calcium Scores are indicative of the presence of Coronary Artery disease.
- Calcium Scores must be interpreted with regards to an age normogram
- Calcium Scores do not indicate the severity of coronary artery stenosis
Calcium Deposition

- Not a passive process but active
- Calcification is part of the inflammatory process
- does it stabilize are plaque?
Coronary Calcium Score
Coronary artery calcium (CAC) is a window to the heart allowing us to visualise coronary atherosclerosis. CAC scoring has emerged as a widely available, consistent, and reproducible excellent way to assess CV risk. CAC testing in asymptomatic populations assess need for anti-platelets and statins improve patient compliance.
Traditional Risk Scoring

**FRAMINGHAM RISK SCORE to predict 10 year ABSOLUTE RISK of CHD EVENT**

- **ST ALBANS & HEMEL HEMPSTEAD NHS TRUST**: CARDIOLOGY DEPARTMENT
- **This risk assessment only applies to assessment for PRIMARY PREVENTION of CHD, in people who do not have evidence of established vascular disease**.
- **Patients who already have evidence of vascular disease should receive a ≥20% risk of further events over 10 years, and require aggressive SECONDARY PREVENTION**.
- **People with a Family History of premature vascular disease are at higher risk than predicted; Southern Europeans and some Asians may have a lower risk in relation to standard risk factors**.

**STEP 1: Add score by sex for Age, Total Cholesterol, HDL-Cholesterol, BP, Diabetes and Smoking.**

<table>
<thead>
<tr>
<th>Age</th>
<th>Total Cholesterol</th>
<th>HDL Cholesterol</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
<th>Diabetes</th>
<th>M</th>
<th>F</th>
<th>Smoking</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 4.1</td>
<td>&gt; 0.9</td>
<td>&lt; 120</td>
<td>No</td>
<td>Yes</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt; 4.1</td>
<td>&gt; 0.9</td>
<td>120-128</td>
<td>No</td>
<td>Yes</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt; 4.1</td>
<td>&gt; 0.9</td>
<td>&gt; 128</td>
<td>Yes</td>
<td>No</td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
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</table>

**STEP 2: Use total score to determine Predicted 10 year Absolute Risk of CHD Event (Coronary Death, Myocardial Infarction, Angina) by sex**

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td>18%</td>
<td>18%</td>
</tr>
<tr>
<td>0-1</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>2-3</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>4-7</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>8-10</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>11-14</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>15-18</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>19-21</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>22-24</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>25-27</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>&gt;27</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

**STEP 3: Compares Predicted 10 year Absolute Risk with “Average” and “Ideal” 10 year Risks, to give Relative Risks**

<table>
<thead>
<tr>
<th>Age</th>
<th>Total Score</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-2</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>3-5</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>6-9</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>10-12</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>13-15</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>16-18</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>19-21</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>22-24</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>&gt;24</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

**Categorization of 10 year Risk of CHD Event**

- **Very Low Risk**: < 10%
- **Low Risk**: > 10% - 16%
- **Moderate Risk**: > 16% - 20%
- **High Risk**: > 20%

**Table:**

- **Comparative Risk**

**Note:** When systolic and diastolic pressure provide different indices in one patient, use the higher number.

**Diabetes:**

- **Yes**: 2
- **No**: 0

**Step 5 (Compared to the same age)**

**CORONARY DISEASE RISK PREDICTION SCORE SHEET FOR MEN BASED ON TOTAL CHOLESTEROL LEVEL**

**Key:**

- **Color**: Green = Very low, White = Low, Yellow = Moderate, Red = High
- **Risk**: Green = Very low, White = Low, Yellow = Moderate, Red = High

**Step 1 (Compares to men of the same age)**

- **Male**: 0
- **Female**: 2

**Step 2 (Determines CHD risk from point total)**

<table>
<thead>
<tr>
<th>CHD Risk</th>
<th>10 yr CHD Risk</th>
<th>10 yr CHD Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>5-12</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>13-18</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>19-24</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>&gt;25</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Step 3 (Total Cholesterol)**

<table>
<thead>
<tr>
<th>Total Cholesterol (mg/dl)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 140</td>
<td>-5</td>
</tr>
<tr>
<td>140-199</td>
<td>-4.5</td>
</tr>
<tr>
<td>199-229</td>
<td>-4</td>
</tr>
<tr>
<td>229-259</td>
<td>-3.5</td>
</tr>
<tr>
<td>&gt;259</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Step 4 (Total Cholesterol)**

<table>
<thead>
<tr>
<th>Total Cholesterol (mmol/l)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3.5</td>
<td>-5</td>
</tr>
<tr>
<td>3.5-5.1</td>
<td>-4.5</td>
</tr>
<tr>
<td>5.1-6.4</td>
<td>-4</td>
</tr>
<tr>
<td>6.4-7.1</td>
<td>-3.5</td>
</tr>
<tr>
<td>&gt;7.1</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Step 5 (Total Cholesterol)**

<table>
<thead>
<tr>
<th>Total Cholesterol (mg/dl)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 160</td>
<td>10</td>
</tr>
<tr>
<td>140-159</td>
<td>6</td>
</tr>
<tr>
<td>120-139</td>
<td>3</td>
</tr>
<tr>
<td>100-119</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 100</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Step 6 (Total Cholesterol)**

<table>
<thead>
<tr>
<th>Total Cholesterol (mmol/l)</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10</td>
<td>10</td>
</tr>
<tr>
<td>8-9.9</td>
<td>6</td>
</tr>
<tr>
<td>7-7.9</td>
<td>3</td>
</tr>
<tr>
<td>&lt; 7</td>
<td>0</td>
</tr>
<tr>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Step 7 (Sum total points)**

<table>
<thead>
<tr>
<th>Age</th>
<th>Total Cholesterol</th>
<th>HDL Cholesterol</th>
<th>Blood Pressure</th>
<th>Diabetes</th>
<th>Smoker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 4.1</td>
<td>&gt; 0.9</td>
<td>&lt; 120</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Coronary Calcification

They establish cardiovascular risk
They reflect exact stenosis levels
They do not see soft plaque
Progression of Calcium
Prediction of cardiac Events by EBCT
Calcium Score & Framingham

Calcium Score 0.81+/-0.03

Framingham Score 0.69+/- 0.03
CALCIUM AND PROGNOSIS

Established as a modality of Stratify risk

Confirmation of Atherosclerosis
Coronary Calcium is a good marker for cardiovascular disease
It assesses atherosclerotic burden
Identifies the at risk patient - not the at risk lesion
Helps us as decision maker to consider further therapy
Simplifies complex ASCVD risk calculators
IMAGING THE CORONARY VESSELS AND ITS ASSOCIATIONS
CACS TO BETTER STRATIFY FUNCTIONAL TESTS

71% of -ve MIBIs have calcium
21% have heavy calcification

Comparative prevalence of coronary artery calcification in patients with normal 99Tcm-MIBI myocardial SPECT versus Calcium Score

National Heart Centre Singapore

Background
The value of myocardial perfusion studies in the diagnosis of patients with Ischaemic Heart Disease (IHD) is well-established. However, it is not sensitive in identifying coronary atherosclerosis. Coronary Artery Calcium Score (CACS) using the multi-slice computer tomography (MSCT) is excellent in diagnosing coronary atherosclerosis. In this study, we compare the prevalence of coronary calcification in patients with a normal 99Tcm-MIBI myocardial SPECT.

Method
A retrospective analysis was performed on patients, who underwent clinically indicated 99Tcm-MIBI myocardial SPECT and CACS in our institution from 2007-2009. A total of 476 patients with clinically driven 99Tcm-MIBI myocardial SPECT and CACS were included in the study. SPECT imaging was performed on a GE scanner either with exercise stress or pharmacologic stress. Calcium scores were obtained using Aquilion One MSCT scanner. SPECT imaging and Calcium score tests were within 6 months of each other with no intervention in between.

Results
The mean age was 56.6 ± SD 10.4. There were 350 males and 126 females. 8.8% of the patients had a positive myocardial perfusion scan. 71% of the patients had coronary calcification as indicated by their CACS. 10.1% (34) of the patients had a Calcium score greater than 1, 30.3% (102) had calcium scores > 10, 31.5% (106) had scores > 100. 69.4% (234) had calcium scores > 400.
In patients with negative MIBI (434), 71% of patients had positive calcium scores. 21% of these cases have calcium score > 400.

Conclusions
In our study, despite having normal cardiac perfusion scans, 71% of cases showed the presence of coronary calcification. Performing a CACS using the MSCT may be a good complimentary tool, in aid with the 99Tcm-MIBI myocardial SPECT in detecting coronary artery disease. This could potentially reduce the false negativity results of the 99Tcm-MIBI myocardial SPECT results. Further studies would need to be done to ascertain this.
A Calcium Score of Zero has a High Negative Predictive Value for Excluding Severe Coronary Artery Stenosis in Symptomatic Patients in an Asian Population

TAY YL1, CHUA SP2, ALLEN JC3, THANJU A1, TAN SY2
1Duke-NUS Graduate Medical School 2National Heart Centre, Singapore

Introduction
Coronary Artery Calcium (CAC) scoring may have potential as a gatekeeper to further testing with Coronary Computed Tomography Angiography (CCTA) or other tests in patients presenting with chest pain and suspected Coronary Artery Disease (CAD). Apart from a subsity of the CONSENSUS Registry, other studies evaluating CAC for this role had limited sample sizes with conflicting results. Moreover, none of these studies were performed in an Asian population. The aim of our study was to assess the Negative Predictive Value (NPV) of CAC scoring for CAD as defined by CCTA in a large symptomatic Asian population.

Coronary Artery Calcification
Coronary artery calcification has been extensively studied and is one of the strongest predictors of future coronary events and mortality. The advantages of CAC are that it is relatively low cost and efficient. However, diseases requiring a lower level of expertise to interpret and does not require the administration of intravenous contrast.

Methods
This was a single center, observational study of all patients referred to our institution for CCTA from March 2007 to September 2012. All patients underwent CAC prior to CCTA on either a 64-Slice or 320-Slice CT using a standard protocol. CAC scores were interpreted using a dedicated work station via the Agatston Scanning. Patients with no symptoms prior infant had known significant CAD, previous revascularization or uninterpretable scans were excluded from the study. Pre-test risk for severe CAD was calculated for patients presenting with chest pain using the Duke Clinical Score. 95% Confidence Intervals (CI) were calculated using the Cochrane–Orcutt Exact method.

Risk Category | Chest pain patients, ≥70% stenosis
--- | ---
High (n=96) | Sensitivity (%) | Specificity (%) | NPV (%) | PPV (%) | 76.5-99.1 | 15.5 | 84.6 | 30.2 | 54.6-98.1 | 20.4-61.1
Intermediate (n=415) | 100.0 | 38.1 | 100.0 | 13.3 | 90.5-100.0 | 33.2-43.1 | 97.5-100.0 | 9.5-17.9 | 82.4-71.5 | 98.1-100.0 | 8.8-17.3
Low (n=661) | 94.7 | 67.1 | 99.7 | 11.3 | 74.0-99.9 | 62.4-71.5 | 98.1-100.0 | 97.9-99.9

Of 1227 symptomatic patients who underwent CAC scoring and CCTA, 527 patients had a CAC score of zero. Four of 327 patients (0.3%) had severe stenosis (≥70% stenosis) while 13 of 527 patients (2.5%) had moderate to severe stenosis (≥50% stenosis) on CCTA. The NPV of CAC score of zero for excluding ≥70% stenosis was 99.2% and for excluding ≥50% stenosis was 97.5%. The NPV of CAC score of zero for excluding ≥70% stenosis in chest pain patients with high intermediate and low risk for severe CAD were 14.6% 100% and 99.7% respectively. The NPV for excluding ≥50% stenosis were 76.5% [96.2-95.0], 96.5% [91.9-99.9] and 99.0% [97.9-99.9].

Conclusion
In a symptomatic Asian population referred for CCTA, a CAC of zero had a high NPV for excluding severe coronary artery stenosis in patients with a low probability of CAD, thus may have potential as a gatekeeper for further testing in this population. In patients with high probability of CAD, CAC of zero does not reliably exclude significant CAD.

References

Acknowledgements
The authors would like to thank May Loh and Hendra Ooi for their invaluable assistance in this project.
Sleeping Less than 6 hours a day is associated with the presence of Coronary Calcification

TAN SY1, MA. NERISSA1, F KENG1, DS SWEE2, TAN PH2, J HUANG2, FK CHEAH2, ES TAI1, RS TAN1, T CHUA1
1National Heart Centre 2SAF Medical Corps 3Department of Radiology, Singapore General Hospital, Singapore

Introduction:
King et al1 recently reported a positive association between the presence of coronary calcium and short sleep duration. In their paper, individuals who reported less hours of sleep had a higher likelihood of developing coronary calcification. On average, one hour less sleep each night was associated with a 16% percent increased likelihood of coronary calcification.

Coronary Calcification:
Coronary calcification has been extensively studied. There have been more than 20 years of clinical data indicating that coronary calcification is one of the strongest predictors of future coronary events.

Figure 1. A patient with coronary calcification in the left anterior descending artery. Such patients have been shown to be at risk from coronary events.

SAFCAP
We recently embarked on the Singapore Armed Forces Coronary Atherosclerosis Project (SAFCAP) which seeks to determine the prevalence of coronary calcium in asymptomatic Singaporean men and determine its relationship with risk factors and other parameters including sleep.

Methods:
531 asymptomatic men from the SAFCAP trial were included in the study. All aged >40 years, were of Asian ethnic origin and had no known diabetes or coronary atherosclerosis. These individuals all had a calcium score done via Multislice Cardiac CT. A positive calcium score was any score more than 0. The reported amount of sleep an individual had was calculated from a patient filled PAQ (Physical Activity Questionaire). The PAQ is based on a questionnaire that has been validated and used in multiple studies done at Stanford University.

Results (Demographics)
Overall, subjects slept a mean of 7.0 hrs (SD 1.07). 27% of subjects who slept more than 6 hours had coronary calcium as opposed to 51% (28/55) of those who slept less than 6 hours (p<0.001).

Conclusion:
There was a significant association between lack of sleep and coronary calcification. Patients who sleep less than 6 hours on average a day are 2.6 times more likely to have coronary calcification, and possibly have a higher risk of cardiac events.

After correcting for potential confounding factors the association appears even stronger with a hazard ratio of 3.0.

There are many factors that affect sleep and therefore further studies are needed to verify this observed association.

Reference:
1. C King et al Short Sleep Duration and Incident Coronary Artery Calcification. JAMA 2008;300(24):2859-2866

Patients who slept less than 6 hours had a HR of 2.6 CI (0.4 – 1.5) p<0.0001 for calcium.

After correcting for age, BMI, hypertension, elevated LDL levels, low HDL levels, elevated total cholesterol, hypertension, hsCRP, The odds ratio actually increased to 3.0 +/- 4.8 and 1.7.
Exercise and the Heart
Current Studies

American College of Sports Medicine, Denver, 2006

Tan SY, Jon Myers, V Froelicher vs. Recent Recreational Activity and All-Cause Mortality
Its all about METS

Relative Risk

- <6
- 6-8
- 8-10
- 10-13
- >13

Relative Risk vs. METS Categories

- Low METS (<6) has the highest relative risk (5.00).
- Medium METS (6-8) has a lower relative risk (3.75).
- High METS (8-10) has a further lower relative risk (2.50).
- Very high METS (10-13) has an even lower relative risk (1.25).
- Extreme METS (>13) has the lowest relative risk (0.00).
Exercise and Mortality in patients without CAD

- 1 MET = 16% reduction in Mortality
- 10yrs of cigarettes extra 9% of mortality

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>HAZARD RATIO FOR DEATH (95% CI)</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal subjects</td>
<td>0.84 (0.79–0.89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>1.09 (1.03–1.14)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pack-yr of smoking (for each 10-yr increment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of hypertension</td>
<td>0.75 (0.56–1.02)</td>
<td>0.07</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.30 (0.84–2.00)</td>
<td>0.24</td>
</tr>
<tr>
<td>Total cholesterol level &gt;220 mg/dl (5.7 mmol/liter)</td>
<td>1.21 (0.88–1.64)</td>
<td>0.25</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>1.22 (0.57–2.63)</td>
<td>0.61</td>
</tr>
<tr>
<td>Exercise-induced ventricular arrhythmia</td>
<td>1.14 (0.64–2.01)</td>
<td>0.66</td>
</tr>
<tr>
<td>Maximal heart rate (for each increment of 10 beats/min)</td>
<td>1.00 (0.92–1.08)</td>
<td>0.93</td>
</tr>
</tbody>
</table>
Exercise and Mortality

EXERCISE CAPACITY AND MORTALITY

Myers et al. EXERCISE CAPACITY AND MORTALITY AMONG MEN REFERRED FOR EXERCISE TESTING NEJM 2002
Calcium and Exercise
Relation of Degree of Physical Activity to Coronary Artery Calcium Score in Asymptomatic Individuals With Multiple Metabolic Risk Factors
Milind Y. Desai, et al AJC 2004
Study on Physical activity in Metabolic syndrome patients

The odds of having a significant CACS (≥100) was half in participants with moderate/high fitness compared with their low fitness counterparts.

Moderate-to-vigorous physical activity, sedentary time and number of components of the metabolic syndrome did only slightly alter the effect size.

Metabolic syndrome had 47% higher odds for significant CAC compared with those without metabolic syndrome.

Being fit is associated with a reduced risk of having significant CAC in individuals with metabolic syndrome.

10,690 asymptomatic patients who underwent CAC scanning. Mortality increased with increasing CAC score (p < 0.001) and decreasing exercise (p < 0.001).

Among patients with CAC scores of 0, mortality was low regardless of the amount of exercise.

Among patients with CAC scores from 1 to 399, there was a stepwise increase in mortality for each reported decrement in exercise, and this difference was markedly more pronounced among patients with CAC scores ≥400.

Compared with highly active patients with a CAC score of 0, highly sedentary patients with CAC scores ≥400 had a 3.1-fold increase (95% confidence interval: 1.35 to 7.11) in adjusted ACM risk.

Among patients with high CAC scores, exercise may play a protective role, whereas reported minimal or no exercise substantially increases clinical risk.

Impact of Exercise on the Relationship Between CAC Scores and All-Cause Mortality.

Arnson Y JACC Cardiovasc Imaging. 2017 Dec
25,972 asymptomatic subjects, who underwent both CACS and treadmill exercise test, was included in the final dataset for analysis.

Exercise capacity $\geq 10$ METs (HR 0.684, 95% CI 0.483-0.971) and CACS $\geq 400$ (HR 3.328, 95% CI 1.850-5.988) were significant predictors of all-cause mortality.

In patients with higher exercise capacity, the effect of high CACS on all-cause mortality was significantly smaller than in those with lower exercise capacity.

The HR for all-cause mortality of CACS $\geq 400$, in those with lower exercise capacity, is estimated to be about three times of that in those with higher exercise capacity (HR 3.328 in $<10$ METs vs. 1.108 in $\geq 10$ METs).

The effect of high CACS on all-cause mortality is lessened by good exercise capacity in the asymptomatic population.

Good physical fitness may reduce the adverse effect of high coronary atherosclerotic burden.

**Combined effects of exercise capacity and coronary atherosclerotic burden on all-cause mortality in asymptomatic Koreans.**

High Physical Activity much lower prevalence of High CAC

**TABLE 3** Logistic Regression Analysis Assessing the Association Between Degree of Physical Activity and Coronary Artery Calcification

<table>
<thead>
<tr>
<th>CAC Score</th>
<th>Moderate PA</th>
<th>Vigorous PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.99 (0.53–1.83)</td>
<td>0.68 (0.40–1.16)*</td>
</tr>
<tr>
<td>Women</td>
<td>0.99 (0.51–1.91)</td>
<td>0.65 (0.38–1.19)*</td>
</tr>
<tr>
<td>&gt;400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1.30 (0.70–2.42)</td>
<td>0.39 (0.19–0.81)†</td>
</tr>
<tr>
<td>Women</td>
<td>1.01 (0.32–3.13)</td>
<td>0.19 (0.04–0.95)‡</td>
</tr>
<tr>
<td>Advanced (≥75th percentile for age and gender)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1.06 (0.63–1.79)</td>
<td>0.54 (0.32–0.93)§</td>
</tr>
<tr>
<td>Women</td>
<td>0.62 (0.30–1.27)</td>
<td>0.39 (0.19–0.78)‡</td>
</tr>
</tbody>
</table>

Nonsignificant but trend for significance, *p = 0.15; †p <0.01; ‡p <0.05. Model adjusted for hypertension, dyslipidemia, obesity, smoking status, and family history of premature CHD.
38% relative increase in the prevalence of advanced CAC in the activity group compared with the long-duration activity group.

Patients who had multiple metabolic risk factors and who engaged in long-duration PA had a significantly decreased associated prevalence of advanced CAC compared with those in the no-PA group.
Marathon runners and high physical fitness
Women marathon runners had minimal coronary artery calcium counts, lower coronary artery plaque prevalence, and less calcified plaque volume compared with sedentary women.

Developing coronary artery plaque in long-term women marathon runners appears related to older age and more cardiac risk factors, although the runners with coronary artery plaque had accumulated significantly more years running marathons.

Long-Term Marathon Running Is Associated with Low Coronary Plaque Formation in Women.
peak oxygen consumption is related to a longitudinal increase in coronary calcium scores.

increased CAC scores over time were significantly less likely in individuals with a higher VO2peak after adjusting for age, gender, hypertension, HbA1c, smoking status and LDL cholesterol levels (p < 0.001).

Aerobic fitness has a protective effect on the progression of coronary atherosclerosis in an asymptomatic middle-aged population

Relationship between aerobic fitness and progression of coronary atherosclerosis.

Sung J. Heart Vessels. 2016 Sep;31(9):1418-23
Heart Rate Recovery

Peak Exercise

- Vagal Release
- Sympathetic activity
- Vagal Activity
- Recovery

HRR <12 in 1 min
HRR <22 in 2 min
Revisiting age-predicted maximal heart rate: Can it be used as a valid measure of effort?

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Abstract

\textbf{Introduction}—Despite high error ranges, age-predicted maximal heart rate (APMHR) is frequently used to gauge the achievement of adequate effort during an exercise test. The current analysis revisits this issue using the Fitness Registry and the Importance of Exercise: National Database (FRIEND Registry).

\textbf{Methods}—A total of 4,796 (63\% male) apparently healthy subjects underwent a maximal cardiopulmonary exercise test on a treadmill. The mean age, maximal heart rate (HR), and maximal aerobic capacity of the cohort were 43 ± 12 years, 178 ± 15 beats per minute, and 36.1 ± 10.6 mlO\textsubscript{2}·kg\textsuperscript{-1}·min\textsuperscript{-1}, respectively. All subjects reached or surpassed a peak respiratory exchange ratio of 1.10. A linear regression equation using age to predict maximal HR was validated in 3,796 subjects and cross-validated in the remaining 1,000 (randomly assigned).

\textbf{Results}—The APMHR equation in the validation cohort was as follows: 209.3 – 0.72(age). The r value and standard error of estimate for this regression was 0.61 (\(P<.001\)) and 11.35 beats/min, respectively. A 1-sample t test revealed that the mean difference between actual maximal HR and APMHR was not significantly different from 0 (mean difference = 0.32, \(P = .33\)). However, Bland-Altman revealed high limits of agreement (upper 25.31 and lower –24.67) and a significant proportional bias.

\textbf{Discussion}—The APMHR equation derived from this analysis included a large cohort of apparently healthy individuals with maximal exercise effort validated by the criterion standard (i.e., peak respiratory exchange ratio). Using APMHR in this capacity should be discouraged, and new approaches to gauging an individual’s exercise effort should be explored.
HRR measure of autonomic health and fitness

attenuated HRR after exercise testing is associated with advanced CAC, independent of coronary risk factors and other related hemodynamic response.

Slow heart rate recovery (HRR) after maximal exercise testing, indicating decreased autonomic function, is associated with an increased risk of cardiovascular event and mortality.

attenuated HRR after exercise testing was associated with advanced CAC, independent of coronary risk factors and other potential hemodynamic confounder, supporting the hypothesis that slow HRR is related to the burden of atherosclerotic coronary artery disease.

Relation of heart rate recovery after exercise testing to coronary artery calcification.

Calcium Score and Intense Exercise

leakage of troponin from the cardiac myocyte membrane rather than myocyte necrosis

athletes, participation in multiple extreme endurance events over a long period of years can lead to abnormal right ventricular (RV) enlargement, dysfunction, and more ominously potentially le-thal arrhythmias
Coronary atherosclerosis can be detected in ~50% of male marathon runners >45 years. Only a minority of these persons have obstructive CAD. Treadmill exercise testing failed to detect these persons.
Marathon runners Paradox

Male athletes are more likely to have a CAC score >300 Agatston units or coronary plaques compared with sedentary males.

The significance of these observations is uncertain, but the predominantly calcific morphology of the plaques in athletes indicates potentially different pathophysiological mechanisms for plaque formation in athletic versus sedentary men.

Coronary plaques are more abundant in athletes, whereas their stable nature could mitigate the risk of plaque rupture and acute myocardial infarction.


transient increases in high-sensitive serum troponin I during a marathon and
108 marathon runners, 864 age-matched controls and 216 age- and risk
factor-matched controls from the general population were recorded
An increase Trop I was observed in 36.5 % of runners
Increasing coronary artery calcium scores and prevalent myocardial
fibrosis, but not increases in Trop I are associated with higher coronary
event rates.

presence of CAC among dedicated lifelong endurance athletes may very
well represent a clinically benign phenotype."

Coronary atherosclerosis burden, but not transient troponin elevation, predicts long-term outcome in recreational marathon runners.
Möhlenkamp S1 Basic Res Cardiol. 2014 Jan;109(1):391
Compared with marathoners with no CAC, marathoners with moderate and extensive CAC were older \((P = 0.002)\), started running at an older age \((P = 0.003)\), were older when they ran their first marathon \((P = 0.006)\).

Among experienced males who have run marathons for 26-34 yr and completed between 27 and 171 marathons, CAC score is related to CAD risk factors and not the number of marathons run or years of running.

This suggests that among long-term marathoners, more endurance exercise is not associated with an increased risk of CAC.

Fifty Men, 3510 Marathons, Cardiac Risk Factors, and Coronary Artery Calcium Scores.
Marathon runners may have higher CAC rates. Plaque type differed among the activity levels. 38% of men in the most active group had calcified plaques compared to 16% in the least active group.
Conclusion

Coronary Calcium scores are an excellent way too identify the at risk patient and can help one decide on risk and future therapy

Presence of coronary calcification implies atherosclerosis is present

Physical Activity has direct impact on cardiovascular health and therefore correlated to coronary calcification

Sedentary individuals have higher CAD levels and as such calcium scores

Marathon runners though have higher prevalence of CACs but may not constitute that high a rocks as the plaque type maybe different and their conditioning mitigated by thicker fitness