Physical Activity and Coronary calcification

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Calcium Scores (CACS)

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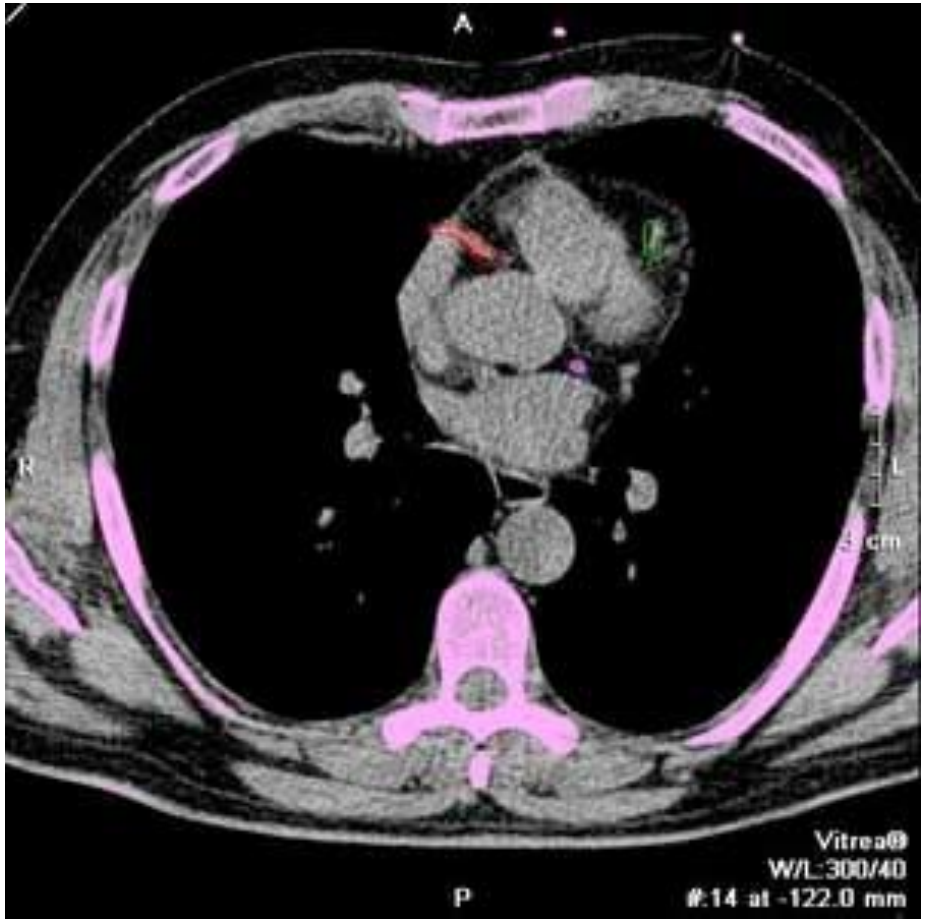
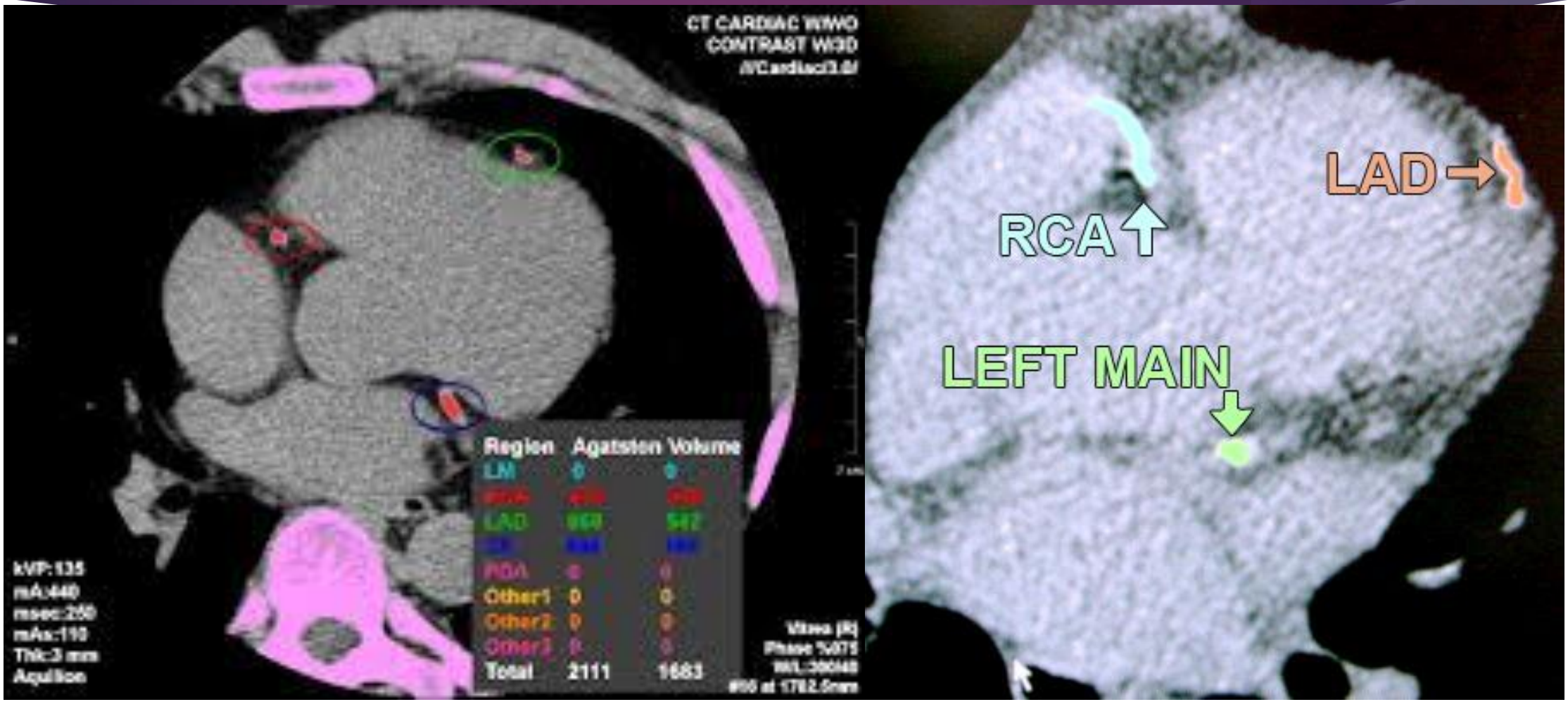
- Calcium Scores are indicative of the presence of Coronary Artery disease.
- Calcium Scores must be interpreted with regards to an age normogram
- Calcium Scores do not indicate the severity of coronary artery stenosis

Calcium Deposition

- Not a passive process but active
- Calcification is part of the inflammatory process
- does it stabilize are plaque ?



Coronary Calcium Score



Coronary 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 usually have a >20% risk of further events of over 10 years, and require vigorous **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 scores by sex for Age, Total Cholesterol, HDL-Cholesterol, BP, Diabetes and Smoking. (If HDL unknown, assume 1.1 in Males, 1.4 in Females)

Age	M	F
30-34	-1	-9
35-39	0	-4
40-44	1	0
45-49	2	3
50-54	3	6
55-59	4	7
60-64	5	8
65-69	6	8
70-74	7	8

Total Cholesterol	M	F
< 4.1	-3	-2
4.1 – 5.1	0	0
5.2 – 6.2	1	1
6.3 – 7.1	2	1
7.2	3	3

HDL Cholesterol	M	F
< 0.9	2	5
0.9 - 1.16	1	2
1.17 - 1.29	0	1
1.30 - 1.55	0	0
≥1.56	-2	-3

Systolic BP	Diastolic BP				
Male	<80	80-84	85-89	90-99	≥100
<120	0	0	1	2	3
120-129	0	0	1	2	3
130-139	1	1	1	2	3
140-159	2	2	2	2	3
≥160	3	3	3	3	3
Female	<80	80-84	85-89	90-99	≥100
<120	-3	0	0	2	3
120-129	0	0	0	2	3
130-139	0	0	0	2	3
140-159	2	2	2	2	3
≥160	3	3	3	3	3

If Systolic and Diastolic BP fall into different categories, use score from higher category

Diabetes	M	F
No	0	0
Yes	2	4

Smoking	M	F
No	0	0
Yes	2	2

Categorisation of 10 year Risk of CHD Event	
Very Low risk	< 10%
Low risk	< 15%
Moderate risk	15-20%
High risk	> 20%

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

Total Score	≤-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	≥17
10 year Risk: Male		<2%	3%	3%	4%	5%	7%	8%	10%	13%	16%	20%	25%	31%	37%	45%	53%	53%	53%	53%
10 year Risk: Female	<1%	2%	2%	2%	3%	3%	4%	4%	5%	6%	7%	8%	10%	11%	13%	15%	18%	20%	24%	27%

STEP 3: Compare Predicted 10 year Absolute Risk with "Average" and "Ideal" 10 year Risks, to give Relative Risks

Age	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74
"Average" Male	3%	5%	7%	11%	14%	16%	21%	25%	30%
"Ideal" Male	2%	3%	4%	4%	6%	7%	9%	11%	14%
"Average" Female	< 1%	< 1%	2%	5%	8%	12%	12%	13%	14%
"Ideal" Female	< 1%	1%	2%	3%	5%	7%	8%	8%	8%

"Ideal" risk represents
Total Cholesterol = 4.1 - 5.1
HDL = 1.2 (Male), 1.4 (Female)
BP < 120/80
No Diabetes, Non Smoker

People with an absolute risk of ≥20% should be considered for treatment: with a Statin to achieve a Total Cholesterol <5 and/or LDL cholesterol <3.2
with anti-hypertensives to achieve a BP ≤160/90 (ideally ≤140/80)

from Wilson PWF, et al Prediction of coronary heart disease using risk factor categories. Circulation 1998;97:1837-47 Dr John Bayliss

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

FPM Tool

Step 1

Age	
Years	Points
30-34	-1
35-39	0
40-44	1
45-49	2
50-54	3
55-59	4
60-64	5
65-69	6
70-74	7

Step 2

Total Cholesterol		
(mg/dl)	(mmol/L)	Points
<160	≤4.14	-3
160-199	4.15-5.17	0
200-239	5.18-6.21	1
240-279	6.22-7.24	2
≥280	≥7.25	3

Key	
Color	Risk
green	Very low
white	Low
yellow	Moderate
rose	High
red	Very high

Step 3

HDL - Cholesterol		
(mg/dl)	(mmol/L)	Points
<35	≤0.90	2
35-44	0.91-1.16	1
45-49	1.17-1.29	0
50-59	1.30-1.55	0
≥60	≥1.56	-2

Step 4

Blood Pressure					
Systolic (mmHg) / Diastolic (mmHg)	<80	80-84	85-89	90-99	≥100
<120	0 pts				
120-129		0 pts			
130-139			1 pt		
140-159				2 pts	
≥160					3 pts

Note: When systolic and diastolic pressures provide different estimates for point scores, use the higher number.

Step 5

Diabetes	
	Points
No	0
Yes	2

Step 6

Smoker	
	Points
No	0
Yes	2

Risk estimates were derived from the experience of the NHLBI's Framingham Heart Study, a predominantly Caucasian population in Massachusetts, USA.

Step 7 (sum from steps 1-6)

Adding up the points	
Age	_____
Total Cholesterol	_____
HDL Cholesterol	_____
Blood Pressure	_____
Diabetes	_____
Smoker	_____
Point Total	_____

Step 8 (determine CHD risk from point total)

CHD Risk	
Point Total	10 Yr CHD Risk
≤-1	2%
0	3%
1	3%
2	4%
3	5%
4	7%
5	8%
6	10%
7	13%
8	16%
9	20%
10	25%
11	31%
12	37%
13	45%
≥14	≥53%

Step 9 (compare to men of the same age)

Comparative Risk		
Age (years)	Average 10 Yr CHD Risk	Low* 10 Yr CHD Risk
30-34	3%	2%
35-39	5%	3%
40-44	7%	4%
45-49	11%	4%
50-54	14%	6%
55-59	16%	7%
60-64	21%	9%
65-69	25%	11%
70-74	30%	14%

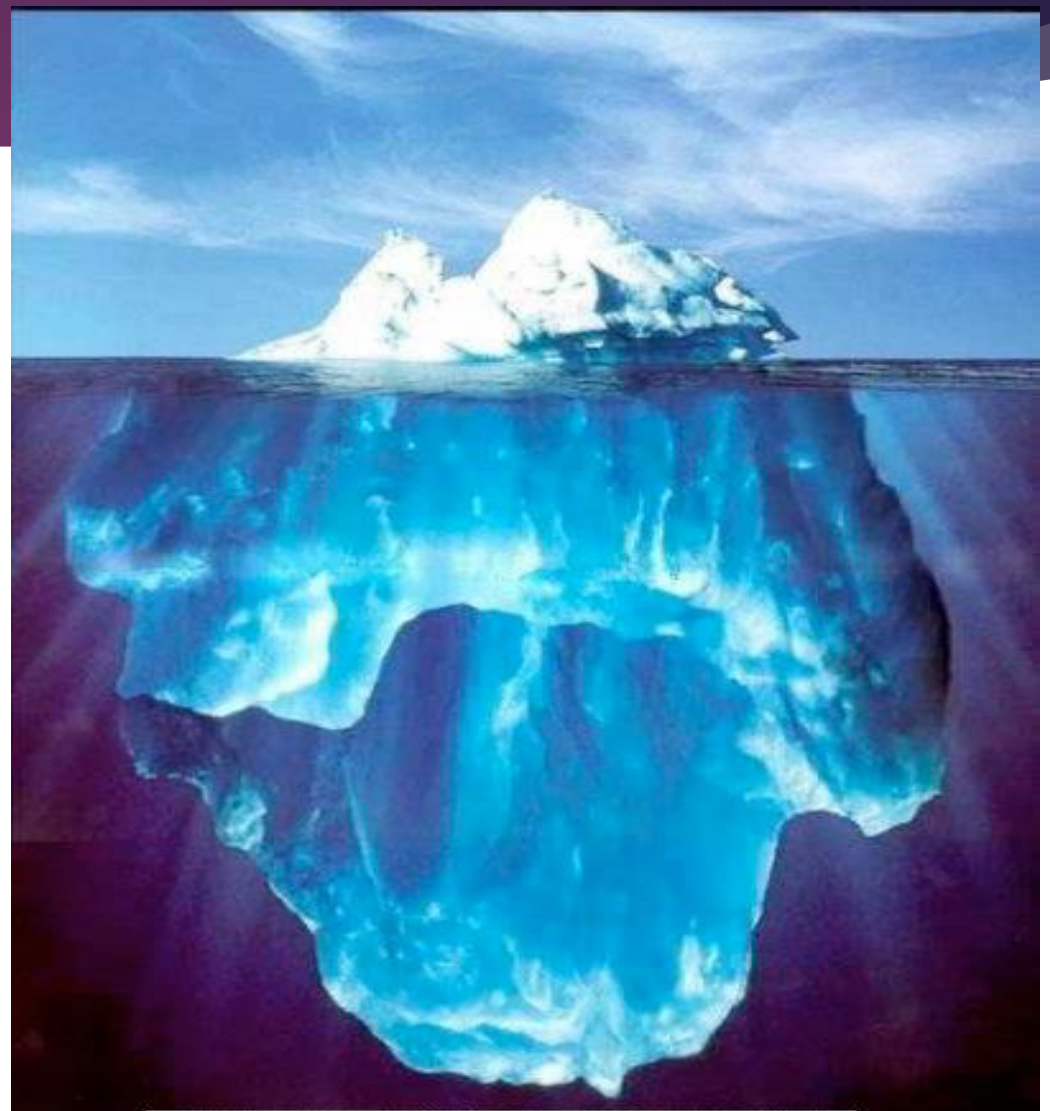
*Low risk was calculated for a man the same age, normal blood pressure, total cholesterol 160-199 mg/dL, HDL cholesterol 45 mg/dL, nonsmoker, no diabetes.

Coronary Calcification

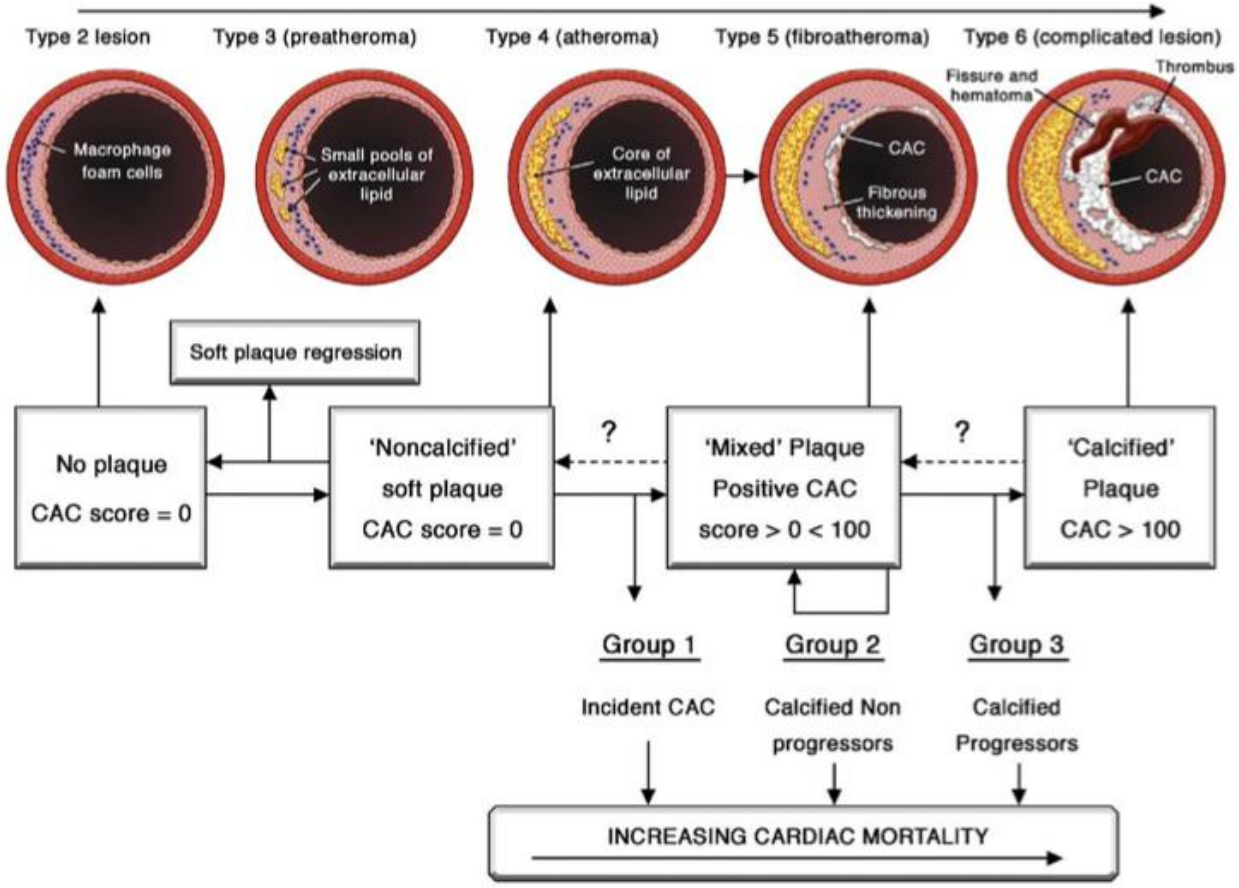
They establish cardiovascular risk

They reflect exact stenosis levels

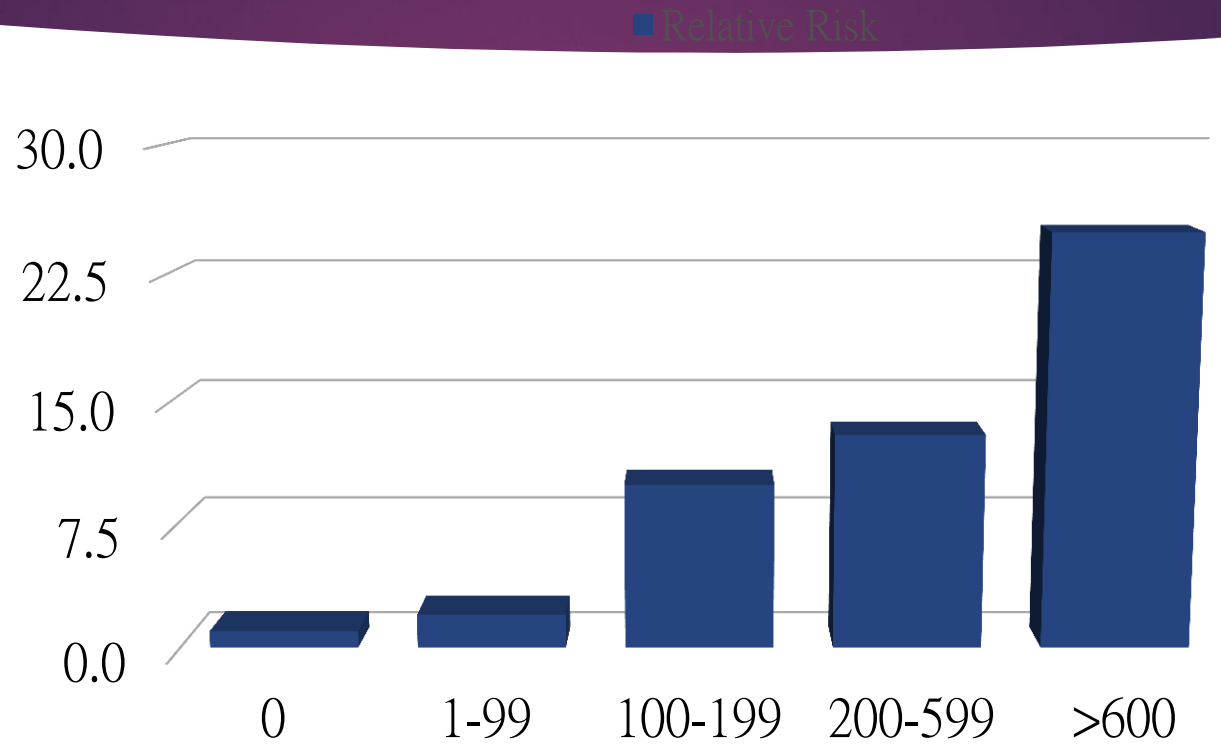
They do not see soft plaque



Progression of Calcium

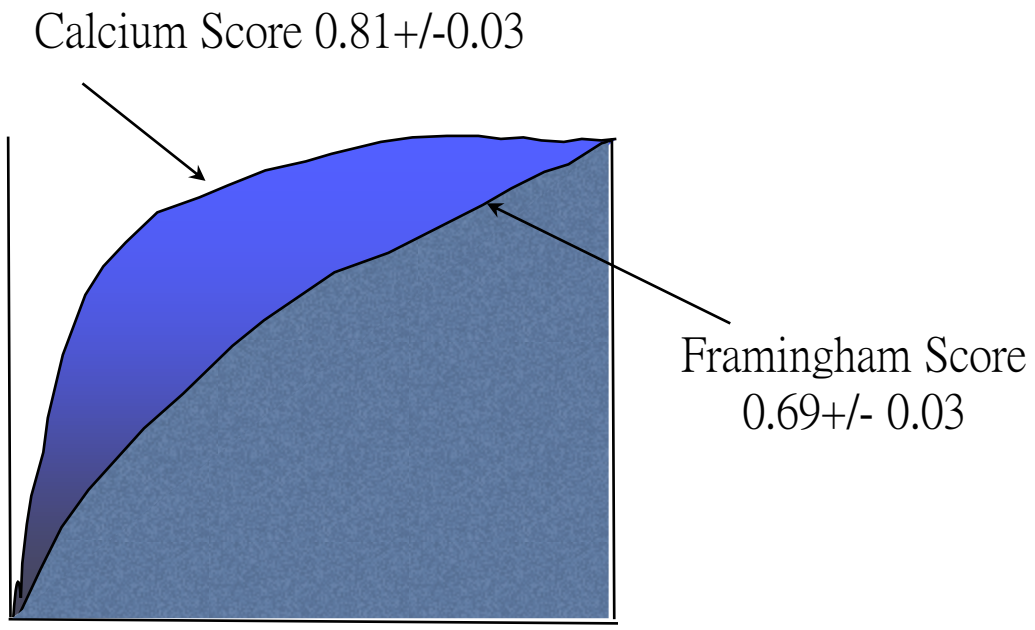


St. Francis Heart Study

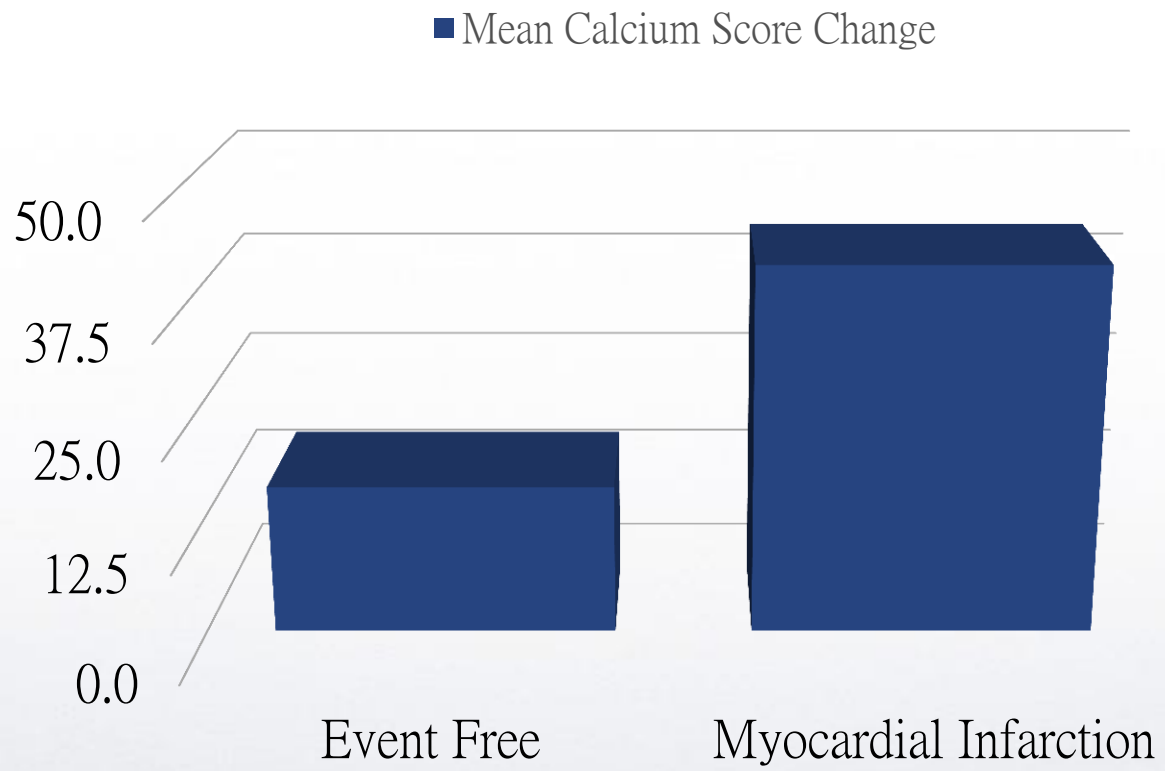


Prediction of cardiac Events by EBCT

Calcium Score & Framingham



CALCIUM AND PROGNOSIS



Raggi P,Callister T,BudoffM,Shaw L.Progression ofcoronary artery calcium and risk offirst myocardial infarction in patients receiving cholesterol-lowering therapy. Arterioscler Thromb Vasc Biol 2004; 24:1272–1277.

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

Simplfies complex ASCVD risk calculators

IMAGING THE CORONARY VESSELS AND ITS ASSOCIATIONS

National Heart Centre Singapore
SingHealth

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

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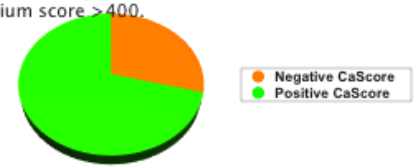
Background
The value of myocardial perfusion studies in the diagnosis of patients with Ischaemic Heart Disease (IHD) is well-established. However, it is not sensitive in identifying coronary atherosclerosis. Coronary Artery Calcium Score (CACS) using the multi-slice computer tomography (MSCT) is excellent 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.



Percentage of patients with Negative MIBI and their respective Calcium Score

Breakdown of study population with Calcium Score

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.

71% of -ve MIBIs have calcium

21% have heavy calcification

CACS TO BETTER STRATIFY FUNCTIONAL TESTS

A Calcium Score of Zero has a High Negative Predictive Value for Excluding Severe Coronary Artery Stenosis in Symptomatic Patients in an Asian Population

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[1]Duke-NUS Graduate Medical School [2]National Heart Centre, Singapore

Author Disclosures:
Chua SJ – National PI for ALTITUDE Study & TRILOGY Trial
All Others – No Disclosures

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 substudy of the CONFIRM 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, involves low radiation doses, requires a lower level of expertise to interpret and does not require the administration of intravenous contrast.

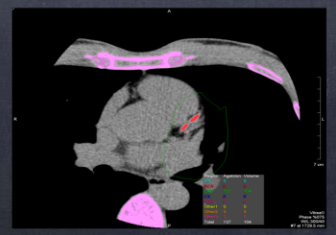

Figure 1. A patient with coronary calcification in the left anterior descending artery. Such patients have been shown to be at risk from coronary events.

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 Schema. Patients with no symptoms, prior infarct, 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 Clopper-Peason Exact method.

Results

Demographics	
Mean Age	55.7 ± 10.9
Mean BMI	25.6 ± 4.3
Male	715 (58.3%)
Female	512 (41.7%)
Symptoms	**Frequency**
Chest Pain	968 (78.9%)
Dyspnea	173 (14.1%)
Others	86 (7.0%)
Risk Factors	**Frequency**
Current Smoker	126 (10.7%)
Hypertension	617 (50.3%)
Dyslipidemia	853 (69.5%)
Diabetes Mellitus	198 (16.1%)
FHx of premature CAD	236 (19.2%)

Degree of Stenosis	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
≥70%	96.4 [91.0-99.0]	46.8 [43.9-49.8]	**99.2** [98.1-99.8]	15.1 [12.6-18.0]
≥50%	96.1 [93.5-97.7]	57.8 [54.4-61.0]	**97.5** [95.8-98.7]	46.3 [42.5-50.1]

Risk Category	*Chest pain patients, ≥70% stenosis*			
	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
High (n=96)	92.9 [76.5-99.1]	15.5 [8.0-26.0]	**84.6** [54.6-98.1]	30.2 [20.8-41.1]
Intermed (n=415)	100.0 [90.5-100.0]	38.1 [33.2-43.1]	**100.0** [97.5-100.0]	13.3 [9.5-17.9]
Low (n=461)	94.7 [74.0-99.9]	67.1 [62.4-71.5]	**99.7** [98.1-100.0]	11.3 [6.8-17.3]

Of 1227 symptomatic patients who underwent CAC scoring and CCTA, 527 patients had a CAC score of zero. Four of 527 patients (0.8%) 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 84.6%, 100% and 99.7% respectively. The NPV for excluding ≥50% stenosis were 76.9% [46.2-95.0], 96.0% [91.4-98.5] and 99.0% [97.0-99.8].

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 an intermediate to low probability of CAD, thus may have potential as a gatekeeper for further testing in this population. In patients with high pretest likelihood of CAD, CAC of zero does not reliably exclude significant CAD.

References:
Villines et al. Prevalence and Severity of Coronary Artery Disease and Adverse Events Among Symptomatic Patients With Coronary Artery Calcification Scores of Zero Undergoing Coronary Computed Tomography Angiography. J.Am.Coll.Cardiol. 2011; Vol. 58, No. 24, 2533–40

Van Werkhoven et al. Impact of Clinical Presentation and Pretest Likelihood on the Relation Between Calcium Acore and Computed Tomographic Coronary Angiography. Am J Cardiol 2010;106:1675-1679

Acknowledgements
The authors would like to thank Max Wu and Kenneth Chew for their invaluable assistance in this project.

SAF Medical Corps

Sleeping Less than 6 hours a day is associated with the presence of Coronary Calcification

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Introduction:

King et al[1] 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 ev

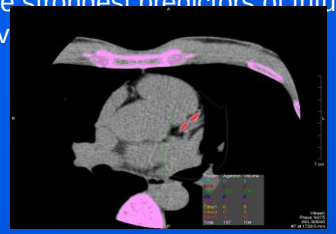


Figure 1. A patient with coronary calcification in the left anterior descending artery. Such patients have been shown to be at risk from coronary events.

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 artherosclerosis. 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.

	Sleep < 6hours (n=55)	Sleep > 6 hours (n=476)	P value
Mean Age	45.2 (44.2-46.3)	44.8 (44.5 – 45.2)	0.117
Smokers	26/55 (47%)	197/476 (41%)	0.40
BMI	24.8 (24.2-25.6)	24.2 (24.0-24.5)	0.39
LDL in mmols	3.54 (3.4-3.7)	3.6 (3.5-3.7)	0.59
HDL in mmols	1.4 (1.3-1.5)	1.3 (1.3-1.4)	0.47
Total Chol	5.6 (5.4-5.8)	5.6(5.5-5.7)	0.98
Diastolic BP	81 (79-82)	82 (80-82)	0.76
Systolic BP	116 (113-119)	118 (116-119)	0.14
hsCRP	0.82 (0.45-1.2)	1.2 (1.01-1.39)	0.19

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.

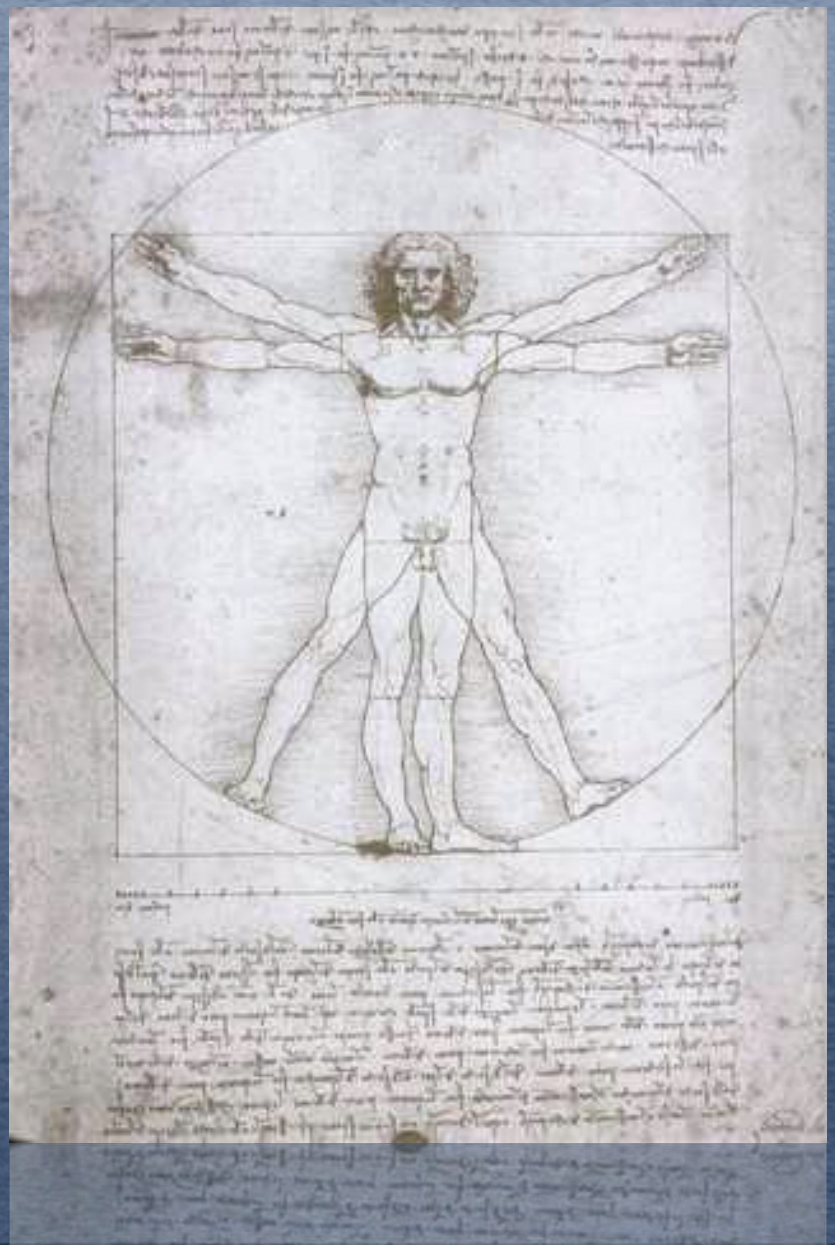
Conclusion:

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 appear 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.

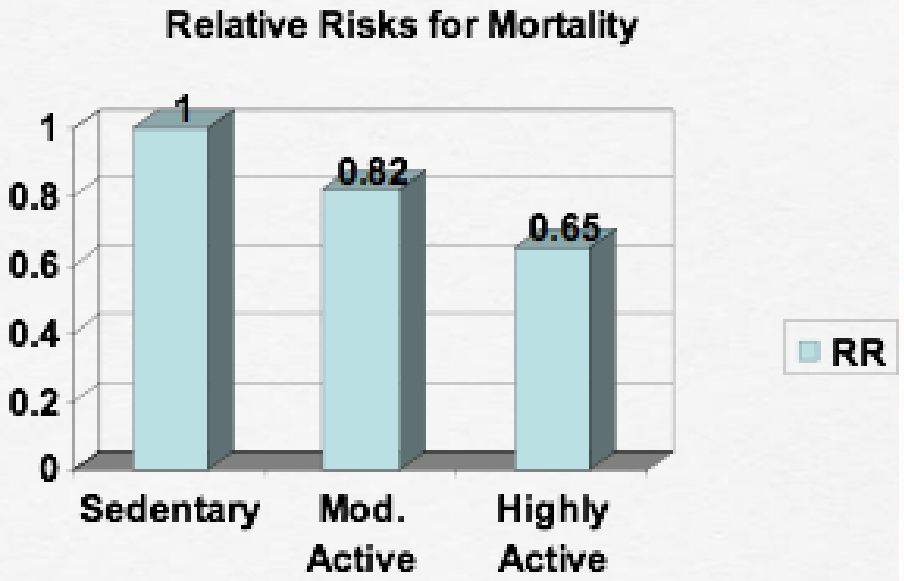
Reference:
1. C King et al Short Sleep Duration and Incident Coronary Artery Calcification. JAMA 2008;300(24):2859-2866

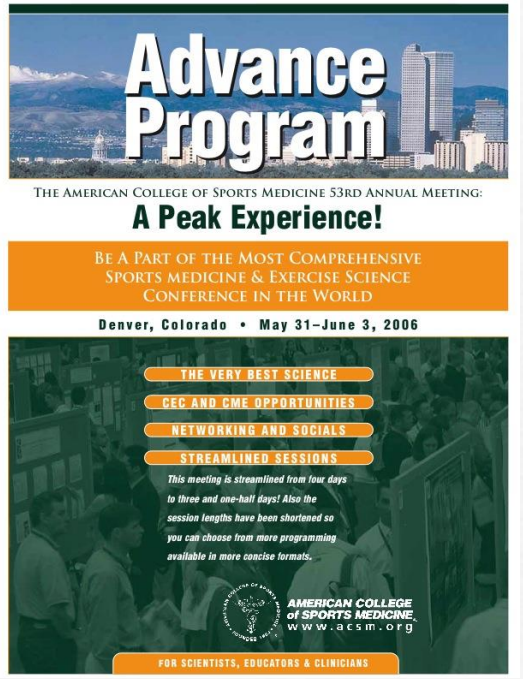
Exercise and the Heart



Current Studies

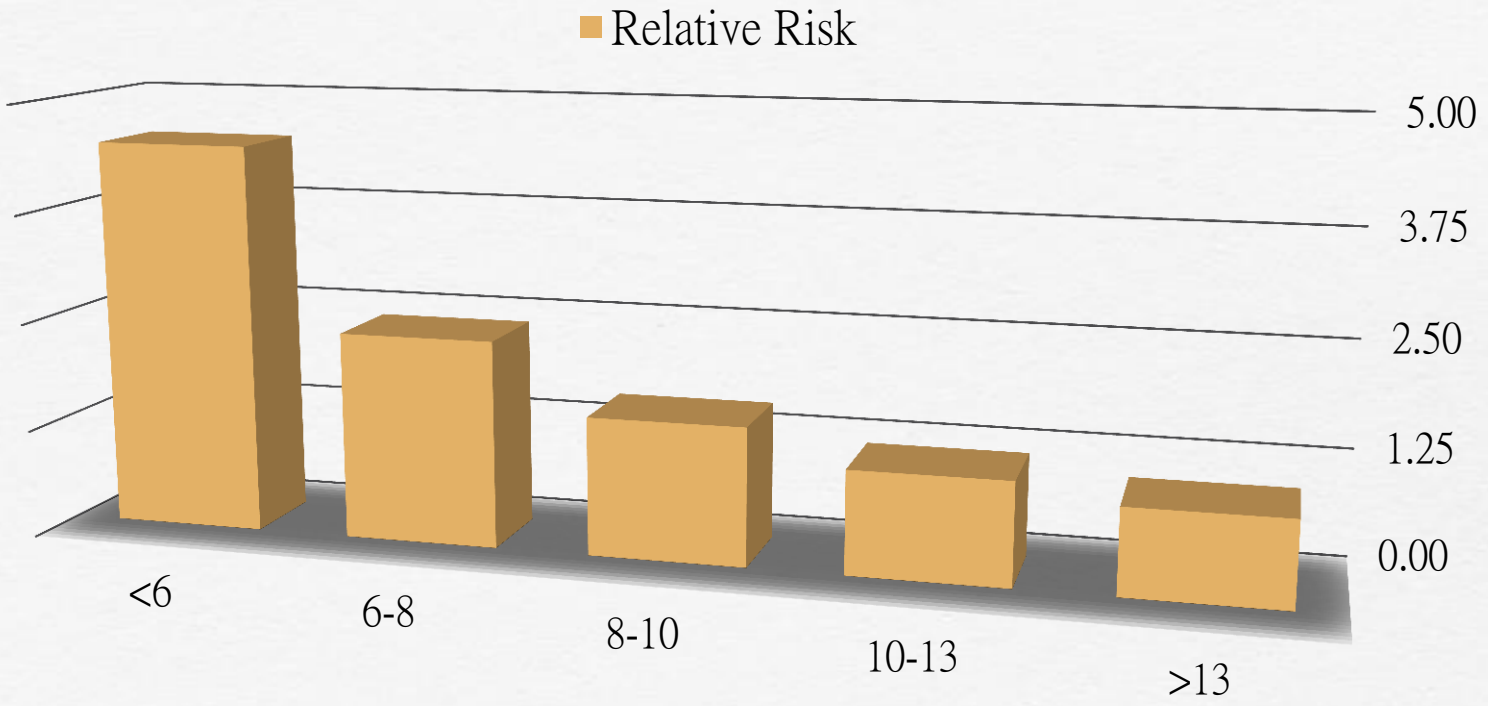
American College of Sports Medicine , Denver, 2006





Tan SY, Jon Myers,V Froelicher vs. Recent Recreational Activity and All-Cause Mortality
Journal of the American Council of Sports Medicine Supplement 2006

Its all about METS

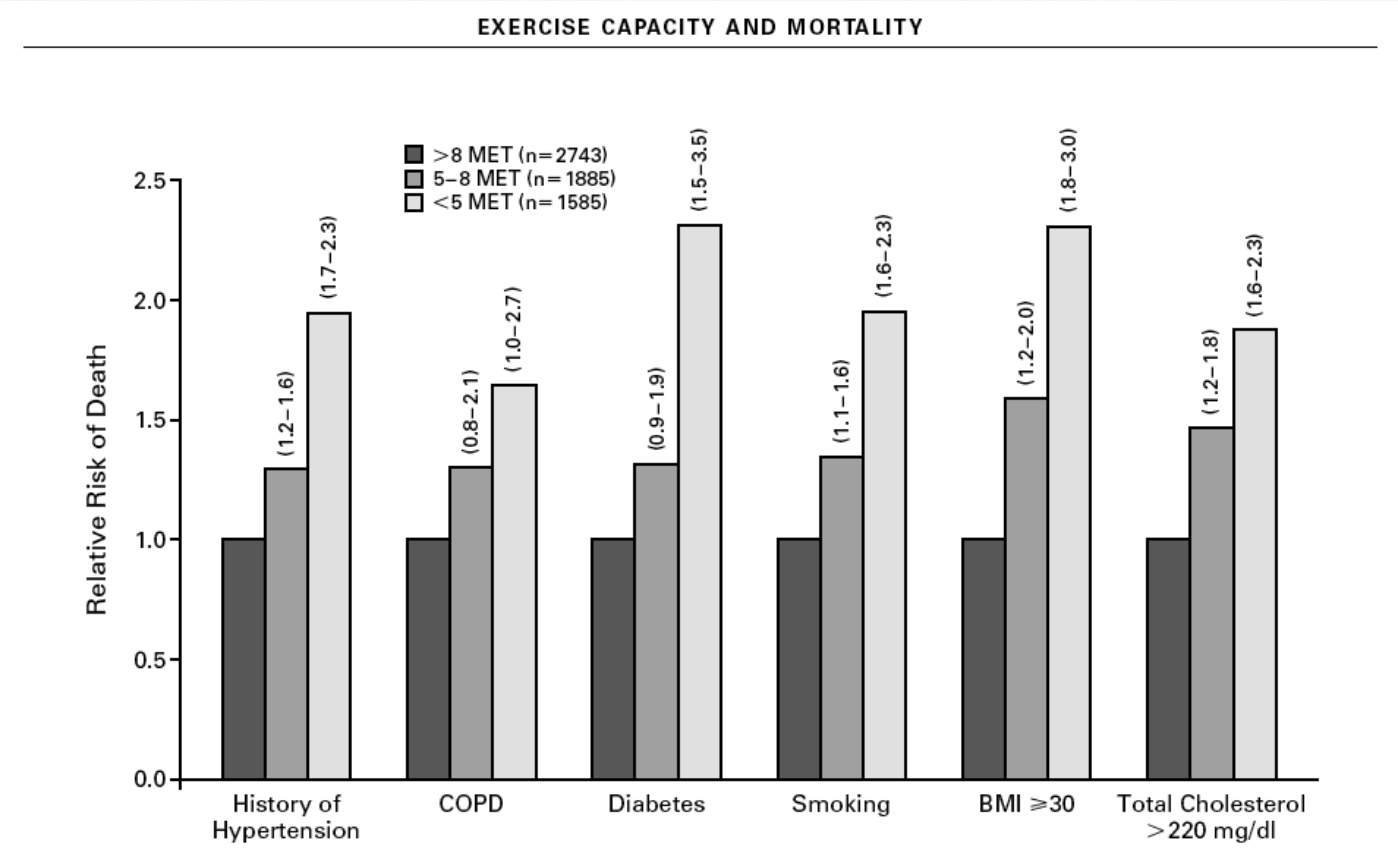


Exercise and Mortality in patients without CAD

Variable	Hazard Ratio for Death (95% CI)	P Value
Normal subjects		
Peak exercise capacity (for each 1-MET increment)	0.84 (0.79–0.89)	<0.001
Pack-yr of smoking (for each 10-yr increment)	1.09 (1.03–1.14)	<0.001
History of hypertension	0.75 (0.56–1.02)	0.07
Diabetes	1.30 (0.84–2.00)	0.24
Total cholesterol level >220 mg/dl (5.7 mmol/liter)	1.21 (0.88–1.64)	0.25
Left ventricular hypertrophy	1.22 (0.57–2.63)	0.61
Exercise-induced ventricular arrhythmia	1.14 (0.64–2.01)	0.66
Maximal heart rate (for each increment of 10 beats/min)	1.00 (0.92–1.08)	0.93

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

Exercise and Mortality



Myers et al. EXERCISE CAPACITY AND MORTALITY AMONG MEN REFERRED FOR EXERCISE TESTING NEJM 2002

Calcium and Exercise

Sedentary Calcium

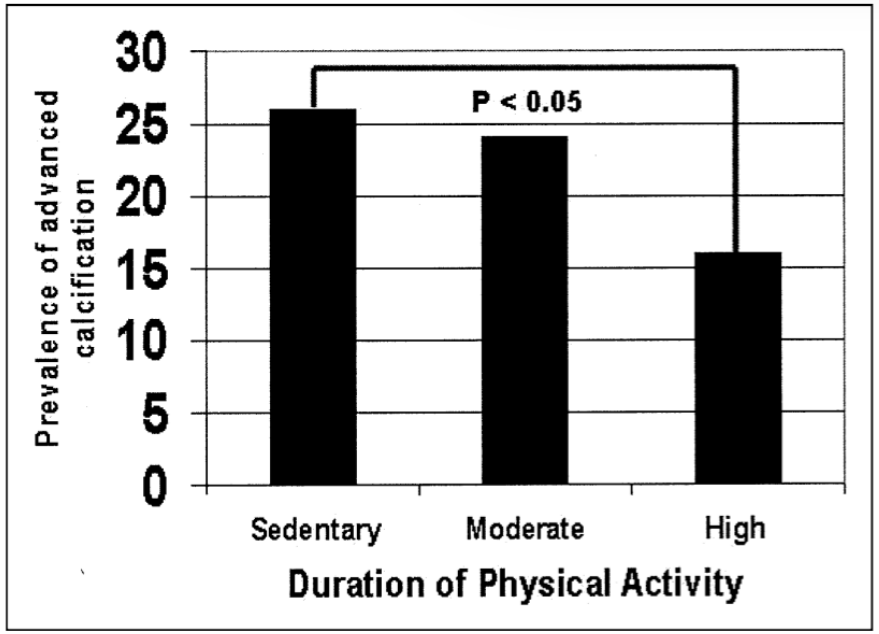


FIGURE 1. Prevalence of advanced CAC (≥75th percentile for age and gender) in the cohort separated on the basis of different degrees of PA. The p value between the no-PA group and the mild to moderate PA group was not statistically significant; p <0.05, long-duration PA group versus mild to moderate-duration PA or no-PA group.

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

Cardiorespiratory Fitness and Coronary Calcium

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.

Fitness attenuates the prevalence of increased coronary artery calcium in individuals with metabolic syndrome.
Ekblom-Bak E Eur J Prev Cardiol. 2018 Feb;25(3):309-316.

Exercise, CACS and All Cause mortality

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

High CACs but Fit

25,972 asymptomatic subjects, who underwent both CACS and treadmill exercise test, was included in the final dataset for analysis. .

exercise capacity ≥10 METs (HR 0.684, 95% CI 0.483-0.971) and CACS ≥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 ≥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 ≥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.

Choi SY Atherosclerosis. 2016 Aug;251:396-403.

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

CAC Score	Moderate PA	Vigorous PA
0		
Men	0.99 (0.53–1.83)	0.68 (0.40–1.16)*
Women	0.99 (0.51–1.91)	0.65 (.038–1.19)*
>400		
Men	1.30 (0.70–2.42)	0.39 (0.19–0.81)†
Women	1.01 (0.32–3.13)	0.19 (0.04–0.95)‡
Advanced (≥75th percentile for age and gender)		
Men	1.06 (0.63–1.79)	0.54 (0.32–0.93)‡
Women	0.62 (0.30–1.27)	0.39 (0.19–0.78)†

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.

Sedentary Patients and CACs

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

Marathon vs Sedentary

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.

Roberts WO Med Sci Sports Exerc. 2017 Apr;49(4):641-645

CAC progression compared to VO2

peak oxygen consumption is related to a longitudinal increase in coronary calcium scores.

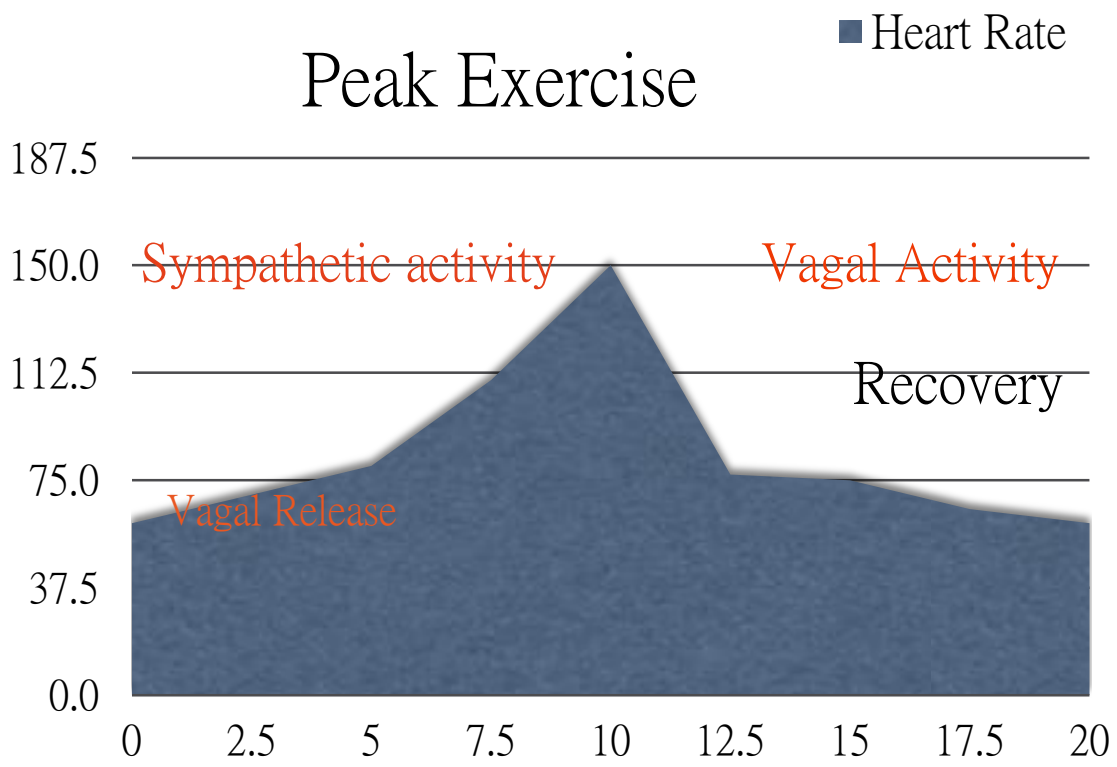
increased CAC scores over time were significantly less likely in individuals with a higher VO2peak after adjusting for age, gender, hypertension, HbA1c, smoking status and LDL cholesterol levels ($p < 0.001$).

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



HRR <12 in 1 min

HRR <22 in 2 min

Published in final edited form as:
Am Heart J. 2016 March ; 173: 49–56. doi:10.1016/j.ahj.2015.12.006.

Revisiting age-predicted maximal heart rate: Can it be used as a valid measure of effort?

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Abstract

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).

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 $mlO_2 \cdot kg^{-1} \cdot min^{-1}$, 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).

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, $P = .43$). However, Bland-Altman revealed high limits of agreement (upper 25.31 and lower −24.67) and a significant proportional bias.

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 (ie, 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.

Heart Rate Recovery and calcium scores

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.

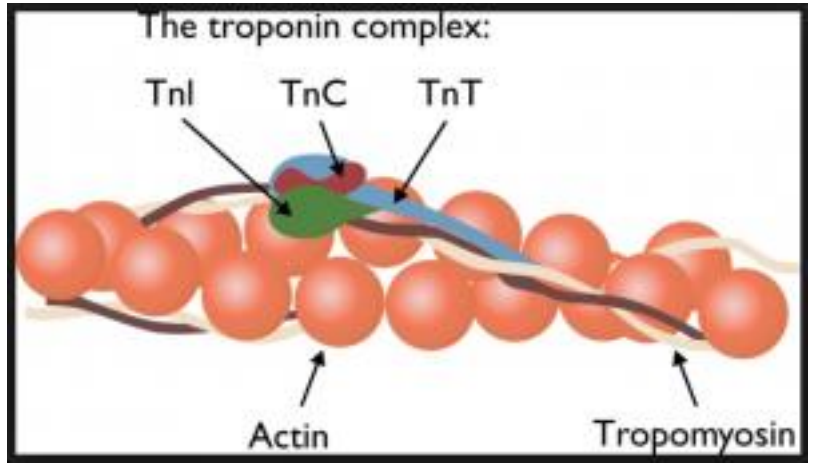
Relation of heart rate recovery after exercise testing to coronary artery calcification.

Jae SY Ann Med. 2017 Aug;49(5):404-410

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



Marathon runners and Coronary calcium

- 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.

Prevalence of Subclinical Coronary Artery Disease in Middle-Aged, Male Marathon Runners Detected by Cardiac CT. Tsiflikas I Rofo. 2015 Jul;187(7):561-8

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.

Coronary and carotid atherosclerosis in asymptomatic male marathon runners.
Burgstahler C Scand J Med Sci Sports. 2018 Apr;28(4)

Prevalence of Subclinical Coronary Artery Disease in Masters Endurance Athletes With a Low Atherosclerotic Risk Profile.
Merghani A Circulation. 2017 Jul 11;136(2):126-137

Marathon - Trop I and Calcium Scores

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

Marathon numbers and calcium

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.

Roberts WO Med Sci Sports Exerc. 2017 Dec;49(12):2369-2373.

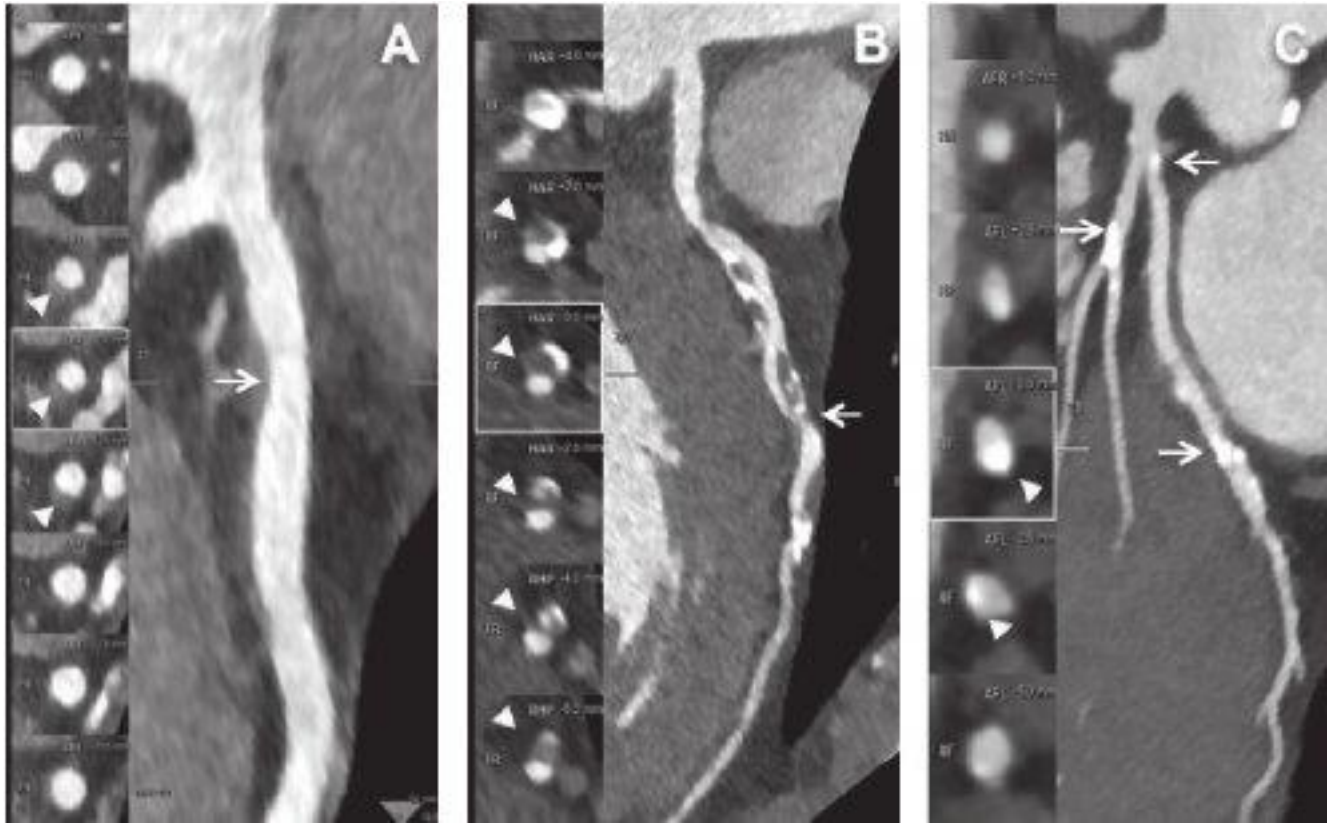
Marathons and type of calcification

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

16% in the least active group.



Soft Mixed Calcified

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

SPCRS 2019 Singapore October 2019

Singapore Prevention and Cardiac Rehabilitation Conference 2019