Comparison of coronary artery calcification scores and National Cholesterol Education Program guidelines for coronary heart disease risk assessment and treatment paradigms in individuals with chronic traumatic spinal cord injury

Jesse A. Lieberman, Flora M. Hammond, Thomas A. Barringer, H. J. Norton, David C. Goff, Jr, William L. Bockenek, William M. Scelza

Physical Medicine and Rehabilitation, Charlotte, NC, USA

Objective: To investigate the risk of coronary heart disease (CHD) in individuals with spinal cord injury (SCI) according to the National Cholesterol Educational Program (NCEP) guidelines and CT coronary artery calcium scores (CCS).

Research: Cross-sectional study of consecutive sample of males with SCI presenting to a single site for CHD risk assessment.

Participants/methods: Males age 45–70 with traumatic SCI (American Spinal Injury Association (ASIA) A, B, and C) injured for at least 10 years with no prior history of clinical CHD. Medical history, blood-pressure, and fasting lipid panel were used to calculate risk for CHD with the use of the Framingham risk score (FRS). Risk and treatment eligibility status was assessed based on NCEP/FRS recommendations and by presence and amount of CCS. Percent agreement (PA) and kappa were calculated between the two algorithms. Spearman correlations were calculated between CCS and FRS and individual risk factors.

Results: A total of 38 men were assessed; 18 (47.4%) had CCS > 0. The PA between NCEP/FRS assessment and CCS was 18% with a kappa of -0.03 . 11 (28.9%) had CCS > 100 or >75th percentile for their age, sex, and race, which might qualify them for lipid-lowering treatment. Only 26 were placed into the same treatment category by NCEP/FRS and CCS, for a PA of 68% with a kappa of 0.35. In all, 20 (52.6%) were eligible for lipid-lowering treatment by either NCEP/FRS ($n=9$) or CCS ($n=11$). Seven subjects were above the treatment threshold based on CCS, but not NCEP/FRS and five subjects were above the NCEP/FRS threshold, but not CCS. Just four subjects were eligible by both algorithms. CCS only correlated with FRS ($r=0.508$, $P=0.001$) and age ($r=0.679$, $P<0.001$).

Keywords: Spinal cord injury, Coronary heart disease, Coronary artery calcium score, Framingham risk score

Introduction

Coronary heart disease (CHD) has emerged as a major cause of mortality in persons with chronic spinal cord injury (SCI), causing or contributing to 22.4% of all deaths in this population.^{1,2} Studies investigating the prevalence of CHD in the SCI population are limited, but one found a prevalence of 17% compared to 7% in

age matched controls.³ Individuals with SCI have also been demonstrated to be at increased risk of prematurely developing CHD.^{4,5} This is most likely because several cardiovascular disease (CVD) risk factors are more prevalent in individuals with chronic SCI compared to age, gender, and race matched able-bodied individuals. These factors include abnormalities of lipid metabolism,^{6,7} glucose intolerance/diabetes,^{8–10} obesity,^{11,12} lack of physical fitness,^{13,14} highly sensitive C-reactive protein,^{10,13,15} and other markers of inflammation and

Correspondence to: Jesse A. Lieberman, Physical Medicine and Rehabilitation, Carolinas Rehabilitation, 1100 Blythe Boulevard, Charlotte, NC 28203, USA. E-mail: Jesse.Lieberman@Carolinashealthcare.org

endothelial activation.¹⁶ High blood pressure is not more common in SCI and may be less common in some subgroups.^{17–19} Despite the increased risk for CHD, insufficient data guides decisions regarding prevention, screening, and treatment for individuals with SCI, especially with respect to management of dyslipidemia.

Currently, the National Cholesterol Education Program (NCEP) guidelines recommend use of the Framingham risk score (FRS) for CHD risk assessment of individuals in the USA. Risk assessment is based on the individual's cholesterol (total cholesterol (TC) and high-density lipoprotein-cholesterol (HDL-C)), age, sex, smoking history, blood pressure level and treatment status, family history, and presence of diabetes.²⁰ The FRS is a multivariable model derived from research done in the general population and is the method most commonly used by practitioners to estimate CHD risk.²¹ However, prediction models that utilize traditional risk factors have great limitations in the individual patient, primarily due to not incorporating various other important risk factors, such as obesity, diet quality, activity level, markers of inflammation, etc. Several studies have demonstrated that the FRS applied to certain populations does not accurately estimate risk of CHD.^{22–24} The application of the FRS may not be appropriate in persons with SCI^{9,10,25}; however, relatively little is known about the performance of the FRS in the SCI population.

CT coronary artery calcium scoring (CCS) is a non-invasive measure of subclinical atherosclerosis. CCS has been demonstrated in various populations to have excellent predictive ability in regard to both CHD events and total mortality.^{26–28} The consistency of these study results prompted the American Heart Association and the American College of Cardiology to issue consensus statements on the role of CCS in cardiovascular risk assessment. Their conclusions are that assessment of CCS is useful for the intermediate risk patient, and adds incremental value in predicting risk of a CHD event.^{29,30}

Only one study has examined CCS in the SCI population, and this study did not report FRS or compare risk assessment between the NCEP approach and CCS.³¹ Whether CCS is feasible and improves risk classification derived from the FRS has not been examined in an SCI population. This study is the first to compare risk assessment from the FRS and NCEP to CCS in a representative SCI sample. In this study, we assessed the prevalence and amount of coronary calcium. We then compared two risk stratification algorithms to determine whether treatment recommendations that might be based on CCS agreed with the NCEP guidelines. If disagreement regarding CHD risk and

treatment eligibility is common in the SCI sample, a strong argument might be made for formal evaluation of the utility of this imaging modality as a screening tool for appropriate persons with SCI.

Methods

Participants

In this cross-sectional study, we enrolled 45 men, aged 45–70 years, with traumatic spinal cord injuries of at least 10 years. They were all American Spinal Injury Association (ASIA) A, B, or C.³² They could not have had any previous history of coronary artery disease. They were recruited with letters sent to their homes and fliers in our outpatient clinic. All participants gave their informed written consent, and the local institutional review board and research review committee approved the study

Risk factors and risk equivalents assessment

Each participant filled out an intake sheet regarding CHD risk equivalents and risk factors as defined by NCEP guidelines. Risk equivalents included clinical CHD, symptomatic carotid artery disease, diabetes, peripheral vascular disease, and abdominal aortic aneurysm. Risk factors included age, smoking history (defined as any cigarette smoking in the last month), family history of premature CHD (CHD in first degree male relative aged <55 years, or first degree female relative aged <65 years), and hypertension (BP $\geq$ 140/90, or antihypertensive medication)²⁰ (Table 1). This information was verified by examining their chart and measuring their blood pressure.

Additionally, subjects with SCI were assessed for 'duration of injury' (in years) and neurologic injury level. Injury level was defined as the first spinal vertebral

Table 1 CHD risk equivalents and risk factors as defined by the NCEP guidelines

Risk equivalents	Criterion
Clinical CHD	
Symptomatic carotid artery disease	Syncopal, TIA, or stroke with >50% stenosis
Peripheral vascular disease	ABI < 0.9, lower limb blood flow studies, or clinical symptoms
Abdominal aortic aneurysm	
Diabetes mellitus	Type I or type II
Risk factors	
Age	Men >45
Smoking history	Any smoking history in the last month
Hypertension	BP > 140/90, or antihypertensive medication
Family history	Premature CHD (in male first-degree relative <55 years, CHD in female first-degree relative <65 years)

level consistent with abnormal neurologic loss (i.e. C2–C8, T1–T12, L1–L5, and S1–S5) and also as complete or incomplete. Complete injury, or ASIA A, was defined as no motor or sensory function in the anal and perineal region representing the lowest sacral (S4–S5) cord; incomplete injury, or ASIA B and C was defined as either sensory incomplete or motor incomplete, respectively.³²

Lipid profiles

Venous blood samples were taken after an overnight fast. TC and triglycerides (TG) were determined using an enzymatic colorimetric test and HDL-C using a homogeneous enzymatic colorimetric test (Beckman Coulter). For participants with TG less than 400 mg/dL, low-density lipoprotein cholesterol (LDL-C) values were determined using the Friedewald equation.³³

Framingham risk score

The FRS was calculated using the risk assessment tool on the NCEP website: <http://hp2010.nhlbi.nih.net/atpiii/calculator.asp>. Lipid profiles (TC, HDL-C) and risk factors (age, gender, systolic blood pressure, current medication use for hypertension, and smoking history) are used in the calculation. The score represents an individual's 10-year risk of having a CHD event.

NCEP risk assessment

Following the NCEP guidelines, we used the LDL-C, presence of CHD risk equivalents, and the FRS to estimate an individual's risk of developing CHD. Participants were assigned to one of four risk categories on the basis of the recommendations provided in ATP III regardless of their lipid-lowering therapy status. The four risk categories were as follows: (1) low risk, defined as 0–1 risk factor for CHD; (2) intermediate low risk, defined as ≥ 2 risk factors and an FRS $< 10\%$; (3) intermediate high risk, defined as ≥ 2 risk factors and an FRS of 10–20%; and (4) high risk, defined as CHD risk equivalent, or an FRS $> 20\%$. Participants were classified according to NCEP-based lipid-lowering drug treatment eligibility based on whether their LDL-C concentration exceeded the risk group-specific treatment initiation thresholds recommended in ATP III: > 190 , 160, 130, and 100 mg/dL for risk groups 1–4, respectively. Participants on a lipid-lowering drug were presumed to have qualified for treatment.

Coronary artery calcium scores

A 64-row multi-detector computed tomography (MDCT) scanner was used to image the heart and assess CCS. This assessment was performed as a gated

examination with helical acquisition utilizing ECG pulsing to reduce radiation dose using a Siemens collimator (24×1.2 mm (64) and 16×1.5 (16)) with 0.24 pitch and 0.37 second rotation time. Typical scan time was 8 seconds using 120 kVp at 300 mAs technique. Images were reconstructed at 3 mm thick $\times 1.5$ increments with reconstruction kernel B35f Heartview medium and the mediastinal window. The participants held their breath for 5–10 seconds while the scan was performed (for individuals on a ventilator the ventilator was managed to accomplish this). Scoring of coronary calcium was automated by the CT scanner software, and studies have shown high reproducibility.³⁴ Each CT scan was then read by a radiologist for incidental findings.

The multi-ethnic study of atherosclerosis (MESA) CCS reference value web tool was used to determine each individual's CCS percentile based on their CCS, age, and race. MESA,³⁵ sponsored by the National Heart Lung and Blood Institute of the National Institutes of Health, is a study of the characteristics of subclinical CVD (disease detected non-invasively before it has produced clinical signs and symptoms) and the risk factors that predict progression to clinically overt CVD. The MESA database included a diverse, population-based sample of 6500 asymptomatic men and women, ages 45–84 years at the initial examination. Approximately 40% of the recruited participants were white, 30% African-American, 20% Hispanic, and 10% Asian, predominantly of Chinese descent.

The MESA CCS reference values web tool provided the estimated probability of non-zero calcium, and the 25th, 50th, 75th, and 90th percentiles of the CCS distribution for a particular age, gender, and race. Additionally, the program provided the estimated percentile for the individual's CCS. At the time of this study, the risk associated with a particular calcium score was unknown. Thus, the information provided by this tool could not be used to conclude definitively that a patient was at 'high risk', but could be used to indicate whether they had a high CCS relative to others with the same age, gender, and race/ethnicity. For this analysis, we defined CCS-based 'high risk' as CCS > 400 or ≥ 75 th percentile for age, sex, and race. Intermediate high risk was defined as individuals with CCS 101–400 and < 75 th percentile for age, sex, and race; intermediate low risk as others with CCS 1–100 and < 75 th percentile for age, sex, and race; and low risk as CCS = 0. These risk classification categories have been used in the general population.^{36,37} Participants were classified according to CCS-based lipid-lowering drug treatment eligibility based on

whether their LDL-C concentration exceeded the risk group-specific treatment initiation thresholds recommended in ATP III applied to the CCS risk categories: >190, 160, 130, and 100 mg/dl for risk groups 1–4, respectively. Participants on a lipid-lowering drug were presumed to have qualified for treatment.

Data analysis

Variables were described using means, standard deviations, and percentages; 95% confidence intervals were calculated for the comparison of the proportion of individuals in this study with CCS > 0 compared to those reported in MESA (49.9%).³⁵ Spearman's correlation coefficients were calculated between CCS, FRS, cholesterol, systolic blood pressure, number of risk factors, level of injury, and duration of injury. Both the NCEP/FRS and CCS-based risk and treatment eligibility classification algorithms were used separately to place each subject into one of the four risk classification categories (i.e. high risk, intermediate high risk, etc.) Agreement between the NCEP/FRS and CCS-based algorithms was examined by estimating percent agreement (PA) and kappa. The PA was defined as the total number of subjects who were classified into either the same risk or treatment classification category by both the NCEP/FRS and CCS algorithms divided by the total number of subjects (i.e. the total number of subjects classified high risk by both algorithms, plus the total number classified intermediate high risk by both algorithms, plus the total number classified intermediate low risk by both algorithms, plus the total number classified low risk by both algorithms, divided by the total number of subjects). The kappa statistic measures the agreement between two ratings that is beyond the role of chance. A kappa of zero indicates the observed agreement between the two risk assessment tools is due to chance, while a kappa of 1 would indicate there is complete agreement.³⁸ The subjects whose CCS placed them in either a higher risk classification category or lower risk classification category compared to their NCEP/FRS category were considered either 'up classified' or 'down classified,' respectively. This technique has been described by Pencina *et al.*³⁹ A *P*-value < 0.05 was considered statistically significant; SAS, version 9.1, software was used for all analyses.

Results

Demographics

A total of 45 males with traumatic spinal cord injuries were enrolled. Three were later excluded: one completed the study, but was later found to be ineligible and the other two were excluded before they underwent any

testing. Four individuals withdrew from the study: one had concerns regarding the radiation from the CT scan, and the other three decided they did not want to be in the study for undisclosed reasons. The remaining 38 individuals' data were analyzed. 9 of the 38 (23.7%) were on lipid-lowering treatment. The descriptive characteristics of the individuals who completed the study are shown in Table 2.

Coronary artery calcium scores

The distribution of CCS by NCEP category and the compliance with NCEP guidelines is shown in Table 3. A total of 18 of the 38 individuals (47.4%, 95% confidence interval (CI) of 31.0–64.2%) had CCS > 0. Overall, 23 individuals were 'down classified' by their CCS scores and 8 individuals were 'up classified' by their CCS scores. The PA between the NCEP risk assessment and the CCS risk assessment was 18%. The PA by chance was 21% and the kappa was -0.03. 11 (28.9%, 95% CI of 15.4–45.9%) had CCS scores >101

Table 2 Descriptive characteristics of study participants

Characteristics	Values
Eligible subjects who completed the full study	38
Non-Hispanic whites	31
African-Americans	7
Asians/Hispanics/native Americans/other	0
Tetraplegics	21 (55.3%)
Paraplegics	17 (44.7%)
ASIA classification	
A	16 (42.1%)
B	16 (42.1%)
C	6 (15.8%)
Mean age + SD (years)	55.0 + 7.2
Time since injury + SD (years)	24.4 + 9.5

Table 3 Risk classification by CCS and NCEP/FRS algorithms

CCS risk categories	NCEP/FRS risk categories				Total
	Low	Intermediate low	Intermediate high	High	
CCS = 0	3	12	3	2	20
CCS = 1–100, <75th percentile	1	0	3	3	7
CCS = 101–400, <75th percentile	0	1	1	0	2
CCS = >400, or >75th percentile	1	2	3	3	9
Total	5	15	10	8	38

or ≥ 75 th percentile for their age, sex, and race placing them in either the intermediate high risk or high risk category. However, 4 of the 11 were considered low or intermediate low risk by their NCEP risk assessment. Of the 18 classified as intermediate high risk or high risk by NCEP criteria, only 7 were in those categories by their CCS. Finally, 9 of 38 (23.7%, 95% CI of 11.4–40.2%) had CCS > 400 or ≥ 75 th percentile for their age, race and gender, indicating a very high risk of a CHD event, yet only 3 of these participants were classified as high risk by NCEP criteria.

We further examined the proportion who qualified for treatment based on CCS and NCEP/FRS algorithms (Table 4). Only 26 of the 38, resulting in a PA of 68%, were placed into the same treatment categories by both CCS and NCEP/FRS algorithms. The PA due to chance was 51% and the kappa for treatment classification was 0.35. Of the 11 deemed eligible for treatment by CCS, only 4 (36.4%) were also deemed eligible by NCEP/FRS.

We examined the treatment of the nine individuals in the CCS-based high risk category as CHD risk equivalents (Table 5); five had LDL-C > 100 mg/dL,

thereby potentially qualifying for drug treatment or intensification, and only two of the five were on lipid-lowering drug therapy. One additional participant was on lipid-lowering drug therapy with an LDL-C < 100 mg/dL.

Relationship between coronary artery calcium scores and individual characteristics

Spearman correlation coefficients were estimated between CCS and individual characteristics, including duration of injury, level of injury, number of risk factors, FRS, HDL-C, as well as systolic blood pressure, TC, TG, and LDL-C. Only FRS ($r = 0.508$, $P = 0.001$) and age ($r = 0.679$, $P < 0.001$) demonstrated significant correlation. None of the other characteristics including duration of injury ($r = 0.000$, $P = 0.999$), number of risk factors ($r = 0.190$, $P = 0.254$), level of injury ($r = 0.138$, $P = 0.409$), HDL-C ($r = 0.120$, $P = 0.475$), systolic blood pressure ($r = 0.130$, $P = 0.438$), TC ($r = -0.049$, $P = 0.770$), TG ($r = -0.034$, $P = 0.842$), or LDL-C ($r = -0.133$, $P = 0.427$) demonstrated a significant correlation with CCS.

Discussion

CVD is a leading cause of death in individuals with chronic SCI, and CHD is responsible for a significant number of these deaths. Our report was consistent with previous findings that CHD, as measured by CCS, is common in individuals with chronic traumatic SCI.³¹ In addition, our findings suggest that the inclusion of CCS with CHD risk factor assessment by FRS may improve the identification of individuals who may require intervention. Of 38 participants, 23 were 'down classified' by their CCS relative to the FRS-based algorithm, whereas eight were 'up classified'. Only 7 of the 38 were classified equivalently by the two risk assessment tools for a PA of 18% and a kappa of essentially zero, indicating that the observed agreement between the two risk assessment tools was due to chance. The PA between the treatment classification algorithms was somewhat better, but it was only 68% with a kappa of 0.35, indicating poor agreement. Only 36.4% of participants who might qualify for treatment based on CCS also qualified for treatment based on the NCEP/FRS algorithm. These results indicate a substantial disagreement between the FRS-based risk and treatment eligibility classification algorithm recommended by the NCEP and the CCS-based algorithm examined in this sample of individuals with chronic SCI.

Due to lack of sensation and/or the ability to do strenuous activity, including activities such as household

Table 4 Eligibility for treatment by CCS and NCEP/FRS algorithms

CCS treatment categories	NCEP/FRS treatment categories		Total
	Above treatment threshold	Not eligible	
Above treatment threshold	4	7	11
Not eligible	5	22	27
Total	9	29	38

Table 5 LDL treatment and control in high-CCS (> 400 or > 75 th%) individuals with SCI

CCS	CCS percentile from MESA reference tool	LDL	Original FRS category	Lipid lowering treatment	LDL-C < 100
422	80	79	Low	Yes	Yes
99	78	158	Intermediate low	No	No
46	86	69	Intermediate low	No	Yes
450	89	112	Intermediate high	No	No
412	94	48	Intermediate high	No	Yes
144	86	143	Intermediate high	No	No
415	78	113	High	Yes	No
252	84	103	High	Yes	No
1049	98	93	High	No	Yes

chores or walking, many individuals with SCI will not manifest typical exertional angina pectoris. Therefore diagnosing CHD prior to a cardiac event must be performed by screening asymptomatic individuals. Asymptomatic heart disease has been reported previously in individuals with chronic SCI undergoing coronary disease evaluation. Bauman *et al.*^{40,41} used thallium-201 myocardial perfusion imaging in small studies of people with tetraplegia and paraplegia to highlight the silent nature of this disease and the need to detect and control risk factors early.^{40,41} They found that participants in these studies had an average of five CHD risk factors. Among those with tetraplegia ($n = 6$), none had symptoms of ischemia, whereas four out of six demonstrated a thallium scintigraphy defect. Of those with paraplegia ($n = 20$), 5 had symptoms of ischemia, whereas 13 (including the 5 with ischemia) demonstrated thallium scintigraphy defects. CCS has also been used in one other published study, which demonstrated an increased atherosclerotic burden in individuals with chronic SCI compared to able-bodied controls. They did not, however, assess whether these individuals met criteria for lipid-lowering drug treatment on the basis of their FRS, nor whether the CCS results would have altered their treatment after assessing their FRS.³¹

In our study, the number of traditional risk factors was not associated with CCS, although age as a single factor and the FRS, which is a composite of age and other risk factors, were associated with CCS. These findings may indicate that there are non-traditional factors, for example, inflammation, that may play a significant role in SCI patients. Recent studies have demonstrated that markers of inflammation and endothelial activation are elevated in individuals with SCI compared to able-bodied controls.^{16,42} Other possibilities include additional CHD risk factors that are not included directly in the FRS, such as glucose intolerance and abdominal obesity.^{8–10,12} The FRS algorithm includes both smoking status and TC; however, Krum *et al.*⁴³ found that the increased risk of CHD in SCI compared to the able-bodied population cannot be explained by differences in TC or smoking. Currently there are not any clinically relevant, validated tools specifically developed to identify adults with SCI at risk for CHD. A valid and practical screening tool such as the FRS applicable to SCI patients could improve risk assessment in persons with SCI.²⁵

The value of screening for CHD with CCS in the general population is still being determined. There are uncertainties with regard to how, when, and in whom the test should be performed, what CCS threshold

should trigger more aggressive treatment of risk factors, and what the most appropriate treatment is once that threshold is crossed.⁴⁴ Because of the minimal data on outcomes of individuals who have previously had CCS, CCS does not meet the criteria for population screening established by the US Preventive Services Task Force.⁴⁵ Their criteria specify that screening and treating persons for early-onset disease should improve the likelihood of favorable health outcomes (e.g. reduced disease-specific morbidity or mortality), as compared with the treatment of patients when they present with signs or symptoms of the disease. In those categorized as having a low risk of coronary events according to the ATP III criteria, the presence of coronary calcium increases the risk of future events, but the likelihood of coronary events remains low. Similarly, for those in the high-risk category, the risk of an event is not precluded by a low CCS. Therefore, attention to risk reduction is warranted regardless of the CCS in high risk persons.

The group most likely to benefit from the additional risk stratification provided by measuring CCS is the intermediate risk group, that is, those with 2+ risk factors and a 10-year risk of $< 20\%$.⁴⁴ An absence of coronary calcium in these patients might shift them to a low-risk category with less need to treat, whereas a high CCS might indicate a higher level of risk that calls for more intensive treatment of modifiable risk factors.^{28,46} A scientific statement from the American Heart Association²⁹ as well as an expert-consensus document from the American College of Cardiology and the American Heart Association³⁰ conclude that it may be reasonable to consider CCS screening in asymptomatic persons identified as having an intermediate risk of coronary events. This view is based on the assumption that such patients with multiple risk factors will be reclassified in a higher risk group based on their CCS and that the management of risk factors will then be intensified.²⁹ In our study, 25 of the 38 participants were in the intermediate risk category, and 10 had CCS > 0 , including 5 with CCS > 101 and 2 with CCS > 400 , indicating substantial proportions whose treatment might be modified.

The major unresolved question is whether utilization of CCS screening will lead to an overall improvement in quality of care and clinical outcomes. Widespread CCS screening runs the risk of increasing the number of unnecessary tests and procedures downstream – including stress imaging, coronary angiography, and revascularization interventions. These tests and procedures can contribute to escalating health care costs and carry their own risks.

In addition, there are concerns regarding cancer risk from the radiation exposure associated with using CT to assess the CCS.^{47–50} The standard chest radiograph yields a radiation dose of 0.01–0.02 mSv.^{47,48} The usual radiation burden associated with CCS scanning is small as well but real (generally, 0.6–1.0 mSv for EBCT and 0.9–2.0 mSv for MDCT).²⁷ Some MDCT imaging protocols are associated with estimated radiation doses higher than 10 mSv.⁴⁹ In the USA, the effective annual background radiation is 3.6 mSv, so the radiation from one CCS scan (~2.0 mSv) approximates to 6.5 months of the effective annual background radiation.⁵¹ An effective dose of 2.3 mSv is estimated to result in a small measurable increase in the risk of cancer.⁴⁹ Therefore, an individual's annual radiation exposure by way of geography, and clinical burden should be part of the consideration, when qualifying risk. This could become an even more important issue if CCS testing (and repeated testing) is used in widespread population screening.

Our study presents several limitations. This is only the second published study using CCS scoring in individuals with SCI. Therefore, it is not known if CCS correlates as well with CHD in the SCI population as in the able-bodied population. Our sample was small (38 individuals), all male, and comprised exclusively of African Americans and Caucasians. This small sample size could have limited our ability to detect correlations between CCS and traditional CHD risk factors. Further testing with a larger sample size may help identify risk factors beyond age and FRS. Women were excluded from this pilot study because they are underrepresented in the SCI population (ratio of men to women 4:1)⁵²; we would therefore have had too few women to draw meaningful conclusions. Additionally, the study was done at a single academic medical center in the southeastern USA. Therefore, a large, multicenter study encompassing multiple ethnicities and both genders will be needed to determine whether CCS may be useful in CHD risk assessment and treatment in the chronic SCI population.

Conclusions

CHD as measured by CCS is common in males aged 45–70 years with chronic traumatic SCI. CCS is associated with age and the FRS, but was not related to duration of injury, total number of risk factors, systolic blood pressure, lipids, or level of injury in this small sample. There is substantial disagreement between the NCEP/FRS risk and treatment eligibility assessments and potential CCS-based assessments in this population. Risk assessment as recommended in the NCEP

guidelines may not estimate the risk of CHD accurately in individuals in the SCI population. CCS could be considered as an adjunct to routine CHD screening for intermediate risk individuals with chronic SCI if these results are confirmed by future studies.

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