

2017

Long term health consequences of chronic spinal cord injury

<https://hdl.handle.net/2144/26561>

"Downloaded from OpenBU. Boston University's institutional repository."

BOSTON UNIVERSITY
SCHOOL OF MEDICINE

Thesis

**LONG TERM HEALTH CONSEQUENCES OF CHRONIC SPINAL CORD
INJURY**

by

KELSEY DONOVAN

B.S., Quinnipiac University, 2013

Submitted in partial fulfillment of the
requirements for the degree of
Master of Science

2017

© 2017 by
Kelsey Donovan
All rights reserved

Approved by

First Reader

Thai Vu, M.S., PA-C
Assistant Professor of Medical Science and Education

Second Reader

Oren Berkowitz, Ph.D., PA-C
Assistant Professor of Medicine

ACKNOWLEDGMENTS

I would like to thank the Boston University Physician Assistant program for allowing me to be a member of the class of 2017 and allowing me the opportunity to step out of my comfort zone to write my thesis. I would also like to thank Thai Vu and Dr. Berkowitz for their support and guidance throughout this process.

Most importantly I would like to recognize Eric Donovan because although you did not choose this journey, your strength does not waver and your motivation is inspiring. Without you, I never would have understood the need for further education, research and comprehensive care for those facing the every day reality of living with a spinal cord injury.

**LONG TERM HEALTH CONSEQUENCES OF CHRONIC SPINAL CORD
INJURY**

KELSEY DONOVAN

ABSTRACT

Background

A spinal cord injury (SCI) often results from a traumatic fracture or dislocation of the vertebral structures causing the spinal cord or surrounding nerves to become bruised, crushed or severed. Spinal cord injuries can leave an individual with a range of deficits from nerve impingement to life-threatening complete paralysis. There are hundreds of thousands of Americans living every day with various forms paralysis. Although advancements in acute care and rehabilitative medicine have transpired, individuals with chronic SCIs combat a number of secondary health complications and frequently encounter premature death.

Literature review findings

The neurologic dysfunction that ensues causes a vast number of secondary health complications including skin breakdown, osteoporosis, diabetes mellitus, dyslipidemia, blood pressure dysfunction, cardiovascular disease and frequently premature death. This comprehensive literature review focuses on these secondary health consequences of chronic spinal cord injuries. Current evidence has presented healthcare providers with guidelines to identify and manage health consequences in the general population. There is a lack of acknowledgement to the SCI population within these guidelines, yet, this subset of patients is, on average, found to have higher rates of osteoporotic fractures, infections,

diabetes, dyslipidemia, cardiovascular events and depression due to their sedentary lifestyles.

Proposed methods

The proposed hypothesis of this study states that Primary Healthcare providers will appropriately identify risk factors for secondary illness and proactively manage long-term care for patients with spinal cord injuries after completing CME training. CME seminars will be available for primary healthcare providers to attend at national AAFP, AAPA and AANP conferences.

Conclusions

A SCI can be one of the most life altering experiences as one's physical, social and psychological welfare are challenged. Beyond these discernible obstacles, lies a life of adverse health consequences linked with significantly reduced lifespans. By educating Physicians, Physician Assistants and Nurse Practitioners about health consequences in the chronic SCI population the care will become centralized and patient-provider relationships will be strengthened.

Clinical Significance

In the current medical model, there is a lack of provider education regarding SCI health consequences and subsequently care becomes fragmented to many different subspecialty providers. Educating the primary healthcare providers creates awareness and supports the need for further research in the field of chronic SCI.

TABLE OF CONTENTS

TITLE.....	i
COPYRIGHT PAGE.....	ii
READER APPROVAL PAGE.....	iii
ACKNOWLEDGMENTS	iv
ABSTRACT	v
TABLE OF CONTENTS	vii
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ABBREVIATIONS	xi
INTRODUCTION	1
Background.....	1
Statement of the Problem	2
Hypothesis	3
Objectives and specific aims	4
REVIEW OF THE LITERATURE	5
Overview	5
Existing research	9
METHODS.....	32

Study Design	32
Study population and sampling	32
Recruitment	33
Curriculum.....	33
Curriculum Assessment.....	34
Study Variables and Measures:	35
Data Collection.....	35
Data Analysis.....	36
Timeline and resources.....	37
Institutional Review Board.....	37
CONCLUSION	38
Discussion.....	38
Summary.....	39
Clinical and/or public health significance	40
APPENDIX 1	41
LIST OF JOURNAL ABBREVIATIONS	42
REFERENCES	43
CURRICULUM VITAE	46

LIST OF TABLES

Table	Title	Page
1	Factors for osteoporotic-fracture	10
2	Predictors of upper and lower extremity osteoporotic-fractures	11
3	Prevention of skin breakdown	13
4	Cardiovascular risk factors for statin vs non-statin SCI study groups	26
5	Learning Objectives for CME Conferences	34

LIST OF FIGURES

Figure	Title	Page
1	Vertebral column	5

LIST OF ABBREVIATIONS

AAFP	American Academy of Family Physicians
AANP	American Association of Nurse Practitioners
AAPA	American Academy of Physician Assistants
BMI	Body Mass Index
CME	Continued Medical Education
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
PA	Physician Assistant
PAG	Physical Activity Guidelines
PTSD	Post-Traumatic Stress Disorder
SCI	Spinal Cord Injury
SCIMS	Spinal Cord Injury Model Systems

INTRODUCTION

Background

Traumatic spinal cord injuries (SCI) typically result from a fracture or dislocation of the vertebral structures that causes injury to the spinal cord disrupting sensory, motor and autonomic signals. Often the spinal cord and axons become bruised or crushed rather than severed leading to a range of deficits from full recovery to complete paralysis¹. There are four segments of the spinal cord; cervical, thoracic, lumbar and sacral. The level at which the injury occurs leads to different manifestations of nerve damage and possible secondary sequelae. Injuries to the cervical region and T1 often result in quadriplegia, also known as tetraplegia. Injuries to this region can also result in paralysis of nerves and muscles necessary for breathing thus requiring emergency surgery or long term use of mechanical respirator. Injuries to the thoracic, lumbar and sacral region can result in paraplegia or more minor and exclusive nerve impairments. Damage to the thoracic region can be divided into two categories of paraplegia. Injury to the T1-T6 spinal cord region results in paraplegia below the mammillary line while injury to the T6-T12 region produces paraplegia below the umbilicus. Damage to the spinal cord in the L1-L5 region results in paraplegia below the waist².

In the hours, days, months and years following a spinal cord injury, patients can face a myriad of health concerns such as hypotension, temperature dysregulation, cardiac arrhythmias, respiratory depression and loss bowel and bladder function. The current research on acute adverse events for SCI is vast and the severity of these events have been directly linked to the severity and location of the SCI. Similarly, outcomes for those

with chronic SCI can depend on the severity and location of the injury and must be identified early to decrease risk of premature death². Patients with SCI are at risk for a significantly reduced lifespan and due to the sedentary lifestyle, are at highest risk for death from infectious, cardiovascular or pulmonary disease processes^{3,4}.

Although cardiovascular and pulmonary events have proven to be the leading causes of mortality, research has yet to provide methods to improve longevity and quality of life in those with SCI⁴. To increase knowledge in this field, autonomic dysfunction and its effects on the cardiovascular, pulmonary, musculoskeletal, integumentary, gastrointestinal and genitourinary function will need to be further investigated. Examination of the pathophysiology of autonomic dysfunction in SCI and modifiable risk factors will be necessary to foster future treatments to decrease morbidity and mortality from cardiopulmonary events⁵. Furthermore, primary healthcare providers such as Physicians, Physician Assistants and Nurse Practitioners have the ability to appropriately manage and proactively treat modifiable risk factors to protect patients with chronic spinal cord injury.

Statement of the Problem

According to the Paralyzed Veterans of America Foundation, there are over 750,000 Americans currently living with SCI³. That is 750,000 Americans who, after surviving the acute phase of the spinal cord injury, will face a life of immense changes to one's physical, social and psychological well-being and independence⁵. Often for those living with spinal cord injuries surviving past the acute phase of recovery, the injury itself is not

the cause of death as secondary infections, cardiac events and suicide become more prevalent⁶. Many of the secondary health concerns these individuals face, such as diabetes, dyslipidemia, coronary artery disease and cardiac events, did not exist prior to their injury and arise prematurely due to a sedentary lifestyle⁷.

Studies have shown an overall decrease in mortality for those with SCI since the 1980s. This is due to an improvement in the most critical acute care and early rehabilitation stages. With this improvement in survival through the acute stage of recovery, the leading cause of death for patients with spinal cord injuries has changed from urologic ailments to cardiovascular and pulmonary events⁶. Several studies illustrate the importance of identifying cardiovascular and pulmonary risk factors such as cigarette smoking, diabetes, hypertension, hypercholesterolemia, reduced pulmonary function and high BMI may be modified to improve morbidity and mortality^{4,7,8}. Modifications of these risk factors can be achieved by combinations of non-medicinal, pharmaceutical, and cardiac rehabilitation to prevent infectious, cardiac and pulmonary events⁹. This education proposal will be used to inform Primary Healthcare Providers about the leading causes of mortality and the associated modifiable risk factors as well as encourage the need for further research in the field to proactively manage the health of SCI.

Hypothesis

Primary Healthcare providers will appropriately identify risk factors for secondary illness and proactively manage long-term care for patients with spinal cord injuries after completing CME training

Objectives and specific aims

The aim of this proposal is to educate primary healthcare providers at a basic level as to what obstacles their patient's may face and how to identify these risk factors early in order to prevent morbidity and mortality. The goal is to more holistically educate the primary provider in order to center the patient's care and allow for the totality of the patient's care to derive from one sole provider.

1. Identify secondary health risks of sedentary lifestyle and manage barriers to reducing inactivity
2. Monitor and manage changes in weight, body habitus and metabolic function leading to obesity
3. Recognize the direct and indirect life-threatening impact that spinal cord injuries have on body systems

REVIEW OF THE LITERATURE

Overview

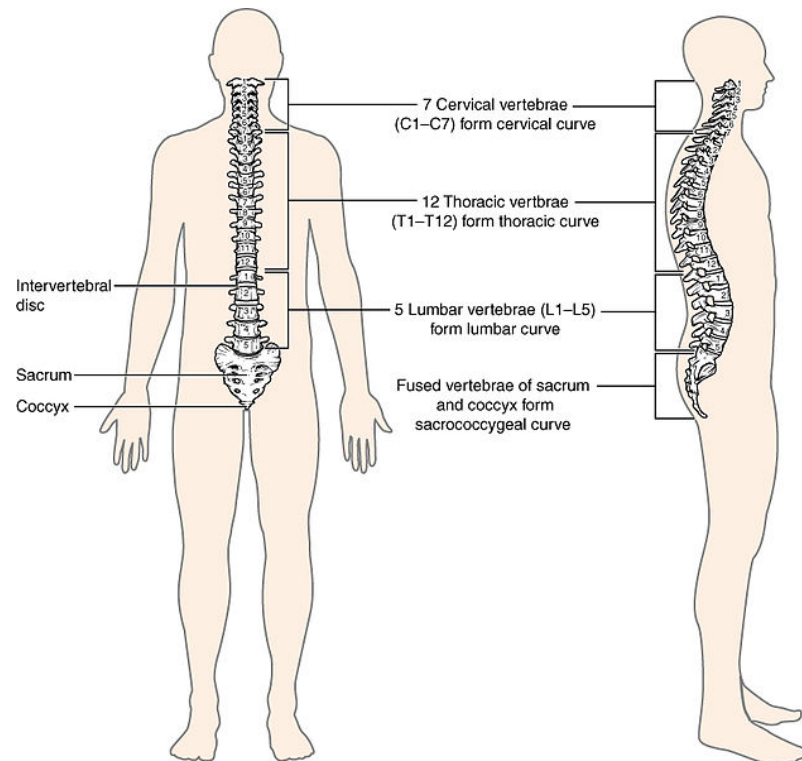


Figure 1. Vertebral Column. Image taken from Anatomy & Physiology, Connexions Website¹⁰

Traumatic spinal cord injuries occur in the United States at a higher rate than any other country¹¹. This is likely due to the number of accident and elderly related injuries in the United States¹². The overall mean age at which spinal cord injuries are occurring has been increasing for the last 50 years. The average age at injury has increased from 28.7 years old in the 1970s to upwards of 40 years old in 2009¹². The median age of injury echoes the median age of the general population¹¹. This is thought to be due to the increasing age and longevity of the general population. In fact, according to the US Census Bureau the number of individuals >65 years old in the general population has

increased 10-fold over the last century. As the general population stays healthier for a longer period of time they also remain more active thus leading to an increase in spinal cord injuries in the 65+ year-old group¹². The average age of injury is expected to continue to increase as the general population ages and lives longer¹¹.

Currently, the majority of spinal cord injuries occur in the young adult population and is often found to be a result of accidents and risky behaviors. Although the average age at injury is increasing, over 50% of SCIs occur in those 16 – 30 years old¹². In the young adult population, men are at nearly three to four times the risk of enduring a spinal cord injury¹¹. Car accidents are the overall leading cause of injury for the US population with other prevalent etiologies including violence, war injuries, recreational sports, and diving incidents. In recent years, the number of injuries caused by gun violence, football, diving and trampoline accidents has declined with the implementation of “injury prevention initiatives¹².” These initiatives bring awareness to spinal cord injuries and methods that can be implemented to protect the body from physical harm. As these initiatives have helped to decrease SCIs from accidents and risky behavior, new evidence is suggestive of an evolving bimodal distribution as there is an increase in injuries in those >65 years old. Observing the elderly population, men and women are affected in a more even distribution. As aging occurs, falls have become the most common etiology of SCI and rates are expected to continue to steadily increase¹¹.

According to the US spinal cord injury database, there has been an increase in the number of individuals experiencing C1-C4 cervical spine injuries and a decrease in those experiencing C5-C8 injuries. Further analysis has shown an increase in incomplete rather

than complete injuries in those who experience C1-C4 injuries. This is thought to be multifactorial as acute therapy and rehabilitative technology has improved survival in this population as well as the fact that many elderly falls result in incomplete tetraplegic spinal cord injury because of C1-C4 fractures¹¹.

As a healthcare provider there is a responsibility to educate and discuss fall prevention with at risk elderly patients. Research has shown that encouraging exercise to strengthen musculature and improve balance may lead to a decrease in falls. Much of the patient's fall risk prevention will be individualized and will require contemplating at the specific obstacles or items in one's home that may pose a problem. Conversations with the aging population should occur before the individual is at high risk for falls as a preventative measure. Research has shown that educational sessions alone can improve fall risk. Items such as rugs and carpet, increase falls both the home and nursing facility settings. Additionally, the patient can be educated to watch foot placement, avoid the use of stairs when possible, and add a cane or walker to daily routines when one first becomes off balance. Medical intervention with vitamin D supplementation has also been shown to decrease fall risk. According to current studies, individual methods have not shown to be superior therefore, when it comes to fall risk prevention in the elderly population, there should be a multidisciplinary approach^{13,14}.

It is important to note that as the general population's lifespan has increased, the overall survival in those with spinal cord injuries has not paralleled the survival curve of the general population. New technology and rehabilitation methods have improved quality of life, morbidity and mortality rates among individuals with SCI in the first 2

years after injury but there continues to be detrimental effects on long-term survival with a SCI. It is likely this discordance is multifactorial. The overall aging process in those with SCI is hastened. Life expectancy can be decreased as much as 9-78% depending upon the severity, age and year of injury¹¹. This range does not include those requiring ventilation, which has been shown to additionally reduce life expectancy.

This research depicts that although the survival gap is narrower, individuals with low severity injuries continue to have a reduced lifespan when compared to the general population. Reduced life expectancy, independent of severity of injury, can be seen in those with injury occurring at 20 years old, 65 years old and 75 years old with average reduced life spans of 31%, 59% and 69% respectively. It is hypothesized that there is a sense of “physiologic reserve capacity¹²” in those injured at a younger age compared to older individuals with the same severity of injury. Many of the older patients require longer hospital stays and will likely not function at a level a younger patient may be able to achieve with rehabilitation¹².

Spinal cord injury research has increased over the last few decades as more awareness has been brought to the alarming discrepancy in lifespan between individuals living with SCI and the general population. Much of the research has gone into providing enhanced acute care, as the majority of deaths after SCI were occurring during this period. As more individuals survive the acute phase in combination with an older average age of injury there has been an increase in observed secondary illnesses. It was not until recent years that research of chronic and secondary illnesses in the SCI population became of significance¹⁵.

Multiple body systems and organs are chronically affected in individuals with SCI including heart, lungs, bowel, kidneys, skin and musculoskeletal as well as psychological well-being. As the normal aging process occurs, the organ systems deteriorate and lead to dysfunction and secondary illnesses. In those with SCIs, comorbidities tend to occur at a younger age and affect survival at higher rates when compared to the general public¹². It is also important to consider is that the older the patient is at the time of the injury, the higher the risk of pre-existing comorbidities at the time of injury which in turn can cause an increase in severity of acute and chronic complications¹¹

Existing research

Sedentary lifestyle

The inability to bear weight and ambulate leads to a decrease in musculature, bone density and an increase in adipose tissue¹². A study completed by the Department of Veterans Affairs using the Veterans Affairs Spinal Cord Dysfunction Registry included 22,516 veterans with a spinal cord injury for greater than 2 years. The study showed an absolute fracture risk of 17% (95% CI 0.14-0.21) at the end of the 11-year study. The purpose of the study was to determine risk factors that can easily be identified by the primary health care provider and in theory decrease the individual's fracture risk. This study was the first and most complete of its kind to explore specific fracture-related risk

factors for those with chronic SCI¹⁶. The leading risk factors, according to *Bethel et al.* (2016), for developing an osteoporotic fracture are summarized in Table 1.

Table 1. Factors for osteoporotic-fracture with SCI by *Bethel et al.* (2016)¹⁶

Risk Factor	Hazards Ratio with 95% CI	p value
White Race	1.18 [1.08, 1.29]	<0.001
Women >50 years old	1.56 [1.18, 2.06]	N/A
Previous hip fracture 1 year prior	4.08 [1.54, 10.77]	<0.001
Previous non-hip fracture 1 year prior	4.01 [2.54, 6.33]	<0.001
Longer duration of injury	1.01 [1.01, 1.01]	<0.001
Comorbidities	1.12 [1.10, 1.14]	0.02
Opioid use	1.36 [1.24, 1.49]	N/A
Anticonvulsant use	1.17 [1.06, 1.28]	N/A
Traumatic etiology	1.16 [1.04, 1.30]	<0.001
Paraplegia	1.09 [1.02, 1.18]	<0.001
Complete spinal cord injury vs incomplete	1.34 [1.24, 1.45]	<0.001

The study illustrates that the highest risk of fracture occurs in those who have had a previous fracture within 1 year. This is likely due to generalized and advanced osteoporosis. Furthermore, it shows that gender alone is not risk factors for fractures with a p-value of 0.61 but there is a significant relationship between women with SCI over the age of 50 and fractures with a hazards ratio of 1.56, 95% CI [1.18, 2.06]¹⁶.

Using the identical sample population, the study determined that lower extremity fractures occurred at a higher rate (80.2%) than upper extremity fractures (19.8%)¹⁶. The data was extrapolated by risk factors for upper and lower extremity fractures.

Table 2. Predictors of upper and lower extremity osteoporotic-fractures by Bethel et al. (2016)¹⁶

Characteristic	HR (95% CI) Upper Extremity	HR (95% CI) Lower Extremity
Women > 50 years old	1.68 [0.94, 2.99]	1.54 [1.12, 2.11]
White Race	1.23 [1.00, 1.50]	1.17 [1.06, 1.30]
Fracture within 1 year	6.50 [2.79, 15.19]	4.06 [2.47, 6.69]
Traumatic etiology	1.33 [1.03, 1.73]	1.35 [1.17, 1.56]
Paraplegia	0.68 [.58, 0.80]	1.23 [1.13, 1.34]
Complete SCI	0.73 [0.61, 0.89]	1.53 [1.40, 1.66]
Comorbidities	1.12 [1.08, 1.17]	1.12 [1.10, 1.14]
Opioids	1.52 [1.23, 1.87]	1.32 [1.18, 1.46]

Bethel et al. (2016), exposed an increased risk for both upper and lower extremity fractures in those categorized by a history of fracture within 1 year, white race, higher number of comorbidities and opioid use. SCI of traumatic origin, paraplegia and complete SCI were found to be positive predictors of lower extremity fractures while being protective against upper extremity fractures. Lastly, a longer duration of injury, women over the age of 50 and those using anticonvulsants were individually found to significantly increase the likelihood of a lower extremity fracture. Further analysis of lower extremity fractures displayed tibia/fibula fractures (25.5%) to be the most common with femur (18.0%) and hip (12.5%) following. Those at highest risk for tibia/fibula fractures were women over the age of 50 with a HR 2.09, 95% CI [1.25, 3.51]¹⁶.

The observed fractures are due to osteoporotic changes initiated by nerve disturbances and decreases in weight bearing. The etiology of bone changes seen in those with SCI differs from the general aging population and post-menopausal women. There is a progressive and accelerated loss of cortical bone over the years that therefore disrupts

bone integrity and leads to fractures. In this specific study, those taking bone protective medications including hormone-replacement therapy, bisphosphonates, calcitonin or denosumab were excluded. The consequence of this exclusion criterion was that women in the Veteran Affairs database were more frequently excluded due to the use of hormone-replacement or osteoporosis medications. Therefore, the absolute fracture risk may not be accurate or generalizable when used for women with SCI. This being said, the study displayed a clear increased risk of lower extremity osteoporotic related fractures, especially tibia/fibula fractures, in women over the age of 50. Interestingly, in the general population women >50 years old are at a particularly high risk for hip fractures but this trend was not observed in this study group¹⁶. It is for these reasons providers may need to use their own discretion when treating women with spinal cord injuries.

Another limitation to the study was missing data for 20% of injury etiologies, 8.7% of level of injury, 17.5% of extent of injury as well as factors including age of menopause, BMI, vitamin D levels, alcohol intake or cigarette use. These missing datasets have the potential to change the observed results and discretion of the provider may have to be taken. Providers should be aware of these identifiable risk factors and discuss the need for pharmaceutical treatment of osteoporosis, strengthening exercises or more modern modes such as robot-assisted weight bearing and ambulation to assist in preventing fractures. Most importantly, if a patient with a SCI reports a prior fracture the provider should be on alert that this patient is at an especially high risk for subsequent fractures¹⁶.

The sedentary lifestyle also increases risk for systemic inflammatory processes, infections and skin breakdown. Implementing routine and consistent skin checks with changes in position often can decrease risk of pressure ulcers¹². According to DeVivo (2012), patients with a SCI have a 30% increased risk of developing a pressure ulcer after the age of 50. In fact, 47% of individuals over 60 years old developed a pressure ulcer upon hospitalization¹¹. Health care providers should discuss the importance and educate their patient's on personal hygiene, weight distribution and position changes, resources and dietary modifications. Simple but important steps can be implemented into one's daily routine to help prevent the development of skin breakdown.

Table 3. Prevention of skin breakdown according to Zanca et al. (2015)¹⁷

• Daily observation of one's skin
• Wear loose clothing
• Prevent moisture from collecting underneath the patient
• Change positions frequently when sitting or in bed
• Carefully transfer between surfaces with proper equipment and supportive cushions
• Periodically check transfer equipment, bedding and wheelchair
• Well balanced diet
• Stay well hydrated
• Smoking cessation

Daily observation of one's skin is an important task in preventing the progression of pressure sores. If skin changes have begun, the caregiver should immediately report the findings to one's health care provider to determine if further treatment or adjustments to the daily routine should occur. This also creates a fluid understanding for both parties and stronger patient-provider relationship. At baseline, patients independently or with the help of a caregiver should change positions every few hours when sitting in a chair or in bed to prevent pressure on one area for an extended period of time. Transferring between

surfaces with the proper equipment is also important and the use of supportive cushions is highly recommended to decrease skin contact with the transfer equipment. Periodic checks of the transfer equipment, bedding and wheelchair should be done to ensure structural integrity. Encouraging bowel and bladder control and hygiene is an important feature to monitor in those with SCI. Decreasing the amount of moisture on or around the patient can prevent infection as well as maintain skin integrity. Other modifications the patient can take are nutritional. A well balanced diet is important to prevent obesity or complications from diabetes. It is important to remind the patient to stay hydrated for skin integrity and not to smoke cigarettes¹⁷.

A method to help remind as well as monitor the patient's understanding and compliance of preventing skin breakdown is by creating a checklist, similar to Table 3, of the preventative measures the patient can take. An educational discussion should take place to give the patient the tools necessary to carry out these daily tasks. Upon subsequent meetings the patient will be able to pinpoint and discuss key successes and difficulties and a conversation can ensue to attempt to reconcile any obstacles. Some common barriers faced may include a shortage of resources or personnel to help the patient with timely shifting in position, transfers or skin checks. These issues can often be combated with changes in wake and sleep schedules, arranging for a visiting nurse to go to the patient's home, ordering new equipment or setting alarms to remind the patient to shift positions¹⁷. It is important to work as a team and assist the patient in ways to overcome the barriers, as prevention of skin breakdown is superior to treating the breakdown and infection after it develops.

Due to the fact that neurological impairment infections may not present as they would in the general population thus increasing the risk of pressure ulcers and the development of septicemia from infections. Although there are developing methods to help counteract obesity, sedentary lifestyle, cardiovascular disease, infections and skin breakdown for those with SCIs, there is a discrepancy in the current healthcare system that splinters care into subspecialty groups. The care often becomes fragmented and patients fall through the gaps allowing preventable disease processes to develop. It is this reason in particular that it is important for primary care providers to become educated and comfortable with assessing risk for secondary illnesses and barriers their SCI patients may face¹¹.

Infections in those with SCI are often a consequence of prolonged or repeated urinary catheterization and pulmonary decline leading to pneumonia¹². Upon initial hospitalization, 30% of those with a spinal cord injury over the age of 60 had developed pneumonia. Pneumonia is also among one of the leading long-term causes of death for those with SCI¹¹. Pneumonia is often caused by decrease nerve innervation of the respiratory tract and a sedentary lifestyle. When the nerve pathway is interrupted it causes a decrease in the patient's ability to cough up secretions as well as a decrease in chest and lung compliance. The patient can also become fatigued much easier. These physiologic changes can be measured by observing a decreased lung volume, forced vital capacity, forced expiratory volume in 1 second⁷. Due to the fact that the population is aging, injuries are occurring at a higher level of the spinal cord and longer injury intervals pneumonia is expected to continue to be a leading cause of morbidity and mortality.

Furthermore, for this reason, it is predicted that there will be an increase in heart disease and cancers while there will be a decrease in secondary injuries and intentional self-harm¹¹.

Body habitus

Sedentary lifestyles and consequential physiologic changes have led to obesity in 75% of the SCI population. Although obesity may be observed, patients with SCI are often not categorized as obese according to their BMI using the general population's inclusion criteria and calculations. It is plausible that inclusion criteria for obesity may need to be adjusted for those with SCI due to the rapid physiologic body composition changes that occur¹². It is often seen that current BMI guidelines misinterprets the ratio of fat to lean tissue in those with spinal cord injuries¹⁸.

Research has shown that many secondary illnesses in the SCI population are due to a combination of inactivity and body composition changes. The major adverse changes to the body include a large and gradual loss of lean body mass and an increase in fat. The muscle loss tends to occur rapidly after the patient's injury and continues to occur as the individual ages¹⁸. A study completed by Nuhlicek et al., further analyzed the body composition changes and observed a decrease in the overall and intracellular water as well as lean body tissue while there was an increase in adipose tissue¹⁹. Bauman and Spungen (2008), who studied the risk factors for coronary heart disease, observed a 3.2% to 1% decrease in lean body mass per decade when comparing a male veteran SCI

population with the general male population. As the lean body mass continues to decrease there is a direct relationship with a decrease in the rate of metabolism¹⁸.

The atrophy that is observed tends to occur greatest in the arms and legs than in the trunk. The study compared the difference between the loss of lean arm tissue in the control group able-bodied population versus those with paraplegia and then the control group with those with tetraplegia. Bauman and Spungen (2008), concluded that there was a significant difference ($p < 0.005$) of lean tissue loss observed in both the paraplegic and tetraplegic study arms when individually compared to the control group. While the study shows significant differences in loss of lean tissue and addition of adiposity between the two groups, there are limitations to the study. The study demonstrates a significant difference between lean body masses, yet it is unable to determine which specific causes are due to genetics, environmental factors or due to the paralysis itself¹⁸.

Additional studies are needed to explore outcome measurements further. This may be achieved by constructing a longitudinal study where participants are observed from the time of injury and followed over their lifetime. Although, this technique poses additional problems including extended periods of follow up and does not exclude genetic and environmental variables. In order to determine the role of genetics in body composition changes between the two groups, monozygotic twins where one twin endures a SCI and one remains able-bodied would have to be studied. Although potentially difficult to carry out, this would allow for control of the genetic variables¹⁸. A similar study to this proposal was carried out by Spungen et al., which observed 8 sets of monozygotic twins with one paralyzed twin in each set. The study showed a significant

decrease ($p < 0.005$) in lean total body mass between the paraplegic monozygotic twins and the able-bodied twins. This study also observed a significant difference ($p < 0.005$) in the total percent of body fat per unit of BMI in the SCI twin study arm. By controlling for genetic variability, this study observed that there is a measurable decrease in lean tissue mass and an increase in adiposity that occurs in patients with spinal cord injuries. The largest difference in lean body tissue between the two groups was found to be in the lower extremities ($p < 0.0005$). Differences in tissue mass of the trunk was found to be lesser than the lower extremities but remained statistically significant ($p < 0.05$). The lean mass that is being referred to is bone and muscle loss from a lack of ambulation²⁰. Bone loss that tends to occur is a loss of cortical bone and a loss of muscle due to little or no nerve innervation²¹.

Cardiovascular disease

The combination of a sedentary lifestyle and obesity rapidly accelerate one's risk for diabetes, metabolic dysfunction and cardiovascular disease. It is for this reason that atherosclerosis and heart disease continue to be leading causes of death in SCI patients^{12,18,22}. A study completed by Whiteneck et al. concluded that 46% of patients in the study group with a SCI for 30 years or greater and 35% of those individuals over the age of 60 died from a cardiovascular event²³. The body and more specifically, the pancreas loses its ability over time to compensate for the slowed metabolism and

worsening carbohydrate metabolism. Carbohydrate metabolism begins to slow and often develops into glucose intolerance or even diabetes¹⁸.

In a study conducted by Bauman et al., 22% of the Veteran SCI population observed was diabetic compared to the 6% seen in the general population arm studied. The study also showed that 82% of the general population was observed to have normal glucose values while only 50% with paraplegia and 38% with tetraplegia were found to have normal glucose concentrations. The peak glucose levels were found to be higher and serum insulin to be lower in the tetraplegic study group. This study showed tetraplegics had a statistically significant ($p < 0.05$) higher rate of glucose intolerance than paraplegics did. Furthermore, gender differences were analyzed and showed that although glucose concentrations were similar, men tended to have a decrease in the amount of insulin in their bodies therefore a higher number of men with SCI are glucose intolerant²⁴.

Glucose intolerance and diabetes mellitus type 2 are two of the principal risk factors for cardiovascular disease and secondary illnesses. The key to this discussion is that diabetes and glucose intolerance can be modified and controlled. It is estimated that greater than 300,000 individuals in the general population die each year because of obesity-endocrine related diseases, thus, making it one of the highest preventable causes of death in the US. Although not directly studied, one can reason that the SCI population would be affected equally, if not more so, as the proportion of diabetes is greater in this population than the general public. As the number of obese individuals, as well as those with diabetes mellitus, continues to rise, so will the predicted number of preventable deaths²⁵. It is the responsibility of the primary provider to monitor for glucose intolerance

or diabetes and to discuss the need for lifestyle modifications or pharmacologic intervention in the spinal cord injury population as it is for the general population. Pharmacologic intervention should be up to the provider's discretion and should be individualized to each patient's needs and glucose values. The regimen should be monitored and further adjusted as time progresses.

In the general population, the combination of a sedentary lifestyle, diabetes mellitus, hypertension and/or dyslipidemia is notorious for producing heart disease. When applied to those living with SCI many of the risk factors have proven to be the same¹⁸. In fact, ischemic and non-ischemic heart disease has been shown to cause 40% of all chronic SCI deaths, therefore, making it the most common cause of death⁷. The only exception to said risk factors is the concept of chronic hypertension in the tetraplegia group¹⁸. More commonly, those with a SCI resulting in tetraplegia have hypotension caused by autonomic dysfunction. In the acute phase, this autonomic dysfunction can lead to life-threatening dysrhythmias and hypotension. After entering the chronic phase, orthostatic hypotension and autonomic dysreflexia are more common⁵. Autonomic dysreflexia occurs most commonly when the injury is above the T6 level, specifically the cervical region. There is a reflexive hypertension that transpires from a lack of control when a stimulus reaches the sympathetic nervous system. The stimuli can be as benign as a full bladder or the urge to empty one's bowels⁹. Patients and their caregivers should monitor bladder and bowel function and intervene if necessary to prevent the harmful stimuli from occurring. Orthostatic hypotension tends to occur in those with chronic SCI due to excess pooling in extremities, muscle loss causing decreased vessel constriction

and blood return to the heart, decreased plasma volume caused by a disruption in the shift of fluids in the extremities, as well as a heart that cannot compensate due to deconditioning⁵⁶⁶⁷. Providers should be aware that autonomic dysreflexia and orthostatic hypotension can be life threatening and it is for this reason patients should monitor for blood pressure changes, both high and low, and be aware of the signs and symptoms.

As hypotension is often seen in tetraplegia, it is not the case for paraplegia. The vasomotor effects are lessened for those with paraplegia and rates of chronic hypertension have been increasing overtime. There is a statistically significant ($p=0.0002$) affect of chronic hypertension on coronary heart disease in paraplegics (32%) compared to the tetraplegic (10%) study arm¹⁸. It is for this reason hypertension should be more vigilantly monitored and maintained below 140/90 in the paraplegic population. Controlling hypertension can be done with lifestyle changes, pharmacologic regimens or decreasing the risk from diabetes mellitus or dyslipidemia. As previously discussed, diabetes should be controlled by pharmacologic or lifestyle changes. The same can be said for dyslipidemia.

Dyslipidemia, specifically an increase in LDL and a decrease in HDL are directly related to an increased risk in cardiovascular disease. Dyslipidemia is often seen in the SCI population and is a leading cause of premature heart disease. According to Bauman and Spungen (2008), 24-40% of individuals studied with SCI had an HDL level less than 35 mg/100ml while the same was true for only 10% of the general population. It is hypothesized that the low HDL level decreases breakdown of LDL, decreases anticoagulation and causes an increase in inflammatory markers, which together can lead

to adverse effects on the arterial vasculature. However, this decrease in HDL has only been observed in the White and Hispanic SCI populations. There was a statistically significant difference, $p < 0.0001$, of mean HDL levels in the White race SCI population compared to the White race able-bodied population. Also noted, was a significant difference, $p < 0.05$, of the HDL levels in the Latino SCI population when compared with the Latino able-bodied HDL levels. When observing the African American SCI study population, there was a statistically significant ($p < 0.0001$) increase in African American HDL levels when respectively compared to the White and Latino sample groups. The study also demonstrated a decrease in the total cholesterol to HDL ratio and a decrease in triglycerides for the African American SCI group. The cholesterol values for African Americans with SCI show no significant difference to the able-bodied African American sample population. At this time, evidence is unclear as to why this occurs¹⁸.

For an individual with SCI and low HDL, there are a number of resources and methods to attempt to raise HDL levels including an increase in physical exercise, smoking cessation and pharmacologic regimens such as statins or bile acid-binding resins. Interestingly, mild amounts of alcohol have been shown to increase HDL values. It has been shown that 1 unit increase in total serum cholesterol:HDL causes a 53% escalation in cardiovascular events in the general population. It is estimated that for every 1 mg/100ml decrease in HDL there is a 2% increase in cardiovascular event in the general population. A similar, if not greater risk, is present for the SCI population as these individuals have been shown to have a significant decrease in HDL levels¹⁸. It has been described that an SCI patient with total serum cholesterol to HDL ratio greater than

5 mg/100ml is considered to be at high risk for a cardiovascular event⁹. If the HDL value reaches as low as 30 mg/100ml or lower and the patient is a male, he may be at an upwards of 20% increased risk of cardiovascular events regardless of other risk factors that may be present. Men with SCI are believed to be at a higher risk than the general population due to the fact that their HDL levels tend to start at lower levels. Therefore early lifestyle modifications or pharmacologic intervention becomes overtly apparent for men with SCI at a younger age. Contrary to men, premenopausal women have been found to have similar HDL levels and cardiovascular risk as the general population of premenopausal women and should be treated comparably¹⁸.

Providers should be attentive to any SCI patient, especially men, with a high LDL:HDL ratio or low HDL value as the risk for cardiovascular disease may be higher than the precedent Framingham risk score. Similarly, providers must be aware that the standard of care, ATP III cholesterol guidelines, recommended by the National Institute of Health may not appropriately apply to patients with a SCI. According to the ATP III guidelines, a patient must meet 3/5 risk factors to be considered to have a metabolic syndrome. The stated risk factors include abdominal obesity defined by waist circumference, hypertension, elevated triglycerides, elevated HDL and an elevated fasting glucose. Although the ATP III guidelines can be generalized to the general public, patients with SCI often do not fit the criteria. In the SCI population, waist circumference may not be increased although the ratio of lean tissue mass to adipose tissue is exceedingly low, tetraplegics are hypotensive, and many are insulin resistant on oral glucose testing but may not present with an elevated fasting glucose. Therefore, providers

may utilize the ATP III guidelines to assist in risk stratification of cardiovascular disease in the SCI population but it should not be used exclusively¹⁸. At this point, without generalizable guidelines to the SCI population, providers must use their discretion when evaluating patients for cardiovascular disease and a multifaceted approach is recommended.

According to Bauman and Spungen (2008), moderate upper extremity exercise for 20-30 minutes a day, three-four days a week for paraplegics has the potential to increase HDL from an average of 39mg/100ml to 47mg/100ml over an eight week time period¹⁸. Improvements in lipid profiles by increasing aerobic activity have been observed in paraplegics but the same cannot be said for tetraplegics⁹. Another aspect of the study reviewed resistance training in five men with spinal cord injuries and was found to have an almost 10% increase in HDL values and a 30% increase in oxygen demand¹⁸. On the contrary, research completed by Totosy de Zepetnek et al., concludes that while the physical activity guidelines (PAG) of 20 minutes of moderate aerobic upper body exercise twice weekly for 16 weeks is important in increasing one's physical health, it has not been shown to significantly improve vascular health. This study examined 21 individuals with 12 in the PAG group and 9 in the control group. Vascular health was measured by "carotid distensability and pulse wave velocity, and endothelial function via flow-mediate dilation. Fasted blood samples were analyzed for markers of cardiovascular disease. Body composition was assessed via anthropometrics and with dual-energy x-ray absorptiometry²⁶." No significant differences in whole body adiposity or mass, organ adiposity or distension of the carotid were found between the PAG and the control group.

The research team suggests the continuation of PAG but also recommends that providers further adjust physical activity, diet and pharmacologic regimens to better protect against cardiovascular disease²⁶. This study had limitations including measuring fasting lipids rather than post-prandial lipids which may have been adjusted by the PAG over 16 weeks as well as they did not control for the individual's diet. Exercise is one part of lifestyle modifications and diet may have as large, if not larger influence on one's cardiovascular health. Also noted, is the need for a larger sample size to enable the researcher to further analyze the response on different levels of injury²⁶.

If lifestyle modifications are found to be inadequate to change the individual's lipid-profile, the most appropriate subsequent step is pharmacologic treatment. HMG CoA Reductase Inhibitors or Statins are considered to be superior to bile acid-binding resins when it comes to treatment of dyslipidemia. Bile acid-binding resins have the tendency to cause bowel dysfunction, upset and often lead to decreased absorption of nutrients and interactions with medications¹⁸. Prior to a study completed by *Stillman et al.*, the spinal cord research field lacked evidence supporting a decrease in cardiovascular disease mortality with the use of a statin drug. This study observed 163 veterans, 98% male and 81% white, all of which with chronic traumatic SCIs. Many of the participants had cardiovascular risk factors including hypertension, diabetes mellitus, obesity, dyslipidemia or smoked cigarettes. One arm of the study observed the effect of statin on cardiovascular health while the control group did not receive treatment. The study group that received statin treatment was found to have a higher burden of cardiovascular risk factors as indicated in table 4⁴.

Table 4. Cardiovascular risk factors for statin vs non-statin SCI study groups by Stillman et al.(2016)⁴⁴⁵⁵⁶

Characteristic	Statin Therapy	Not on Statin Therapy	p-value
Hypertension	50 (69)*	26 (37)*	0.0001
Diabetes Mellitus	27 (36)*	10 (13)*	0.0009
Hyperlipidemia	57 (78)*	11 (16)*	<0.0001
% with BMI >25	68*	37*	0.0002
Current Smoker	28 (38)*	34 (42)*	0.60
Total Cholesterol	164 ± 49**	160 ± 30 **	0.56
Triglycerides	146 ± 69**	139 ± 143**	0.092
LDL Cholesterol	108 ± 44**	101 ± 29**	0.28
HDL Cholesterol	42 ± 38**	29 ± 13**	0.62

*n (%)

** mean ± standard deviation

There were significant burdens of cardiovascular disease risk factors such as hypertension, diabetes mellitus, hyperlipidemia and those with BMI >25% for the statin therapy study group. The study results revealed that regardless of having a larger cardiovascular burden in the statin therapy group, there was a significant decrease of p=0.0087 in mortality when compared to the control group. The statin group observed a mortality rate of 37% compared to 58% seen in the control group. This study also revealed that differences in the strength or duration of statin treatment did not significantly (p=0.071) affect mortality rate. This has been noted to be a key limitation to the study as more recent research completed in the “Prove-It” and “TNT” studies that high intensity Atorvastatin 80 mg is superior to Atorvastatin 40mg in decreasing cardiovascular events. The limitation is likely due to the sample size, analysis and retrospective bias. Although the objective of the study was to demonstrate that statin treatment is a significant secondary treatment for cardiovascular disease, the study

population does not allow for generalizability to women or non-white races. Additional studies are necessary in this field to prospectively study the most appropriate time to initiate statin therapy, for what duration and at what strength for each individualized SCI patient⁴.

Early identification of the detrimental risk factors an individual may have can assist in prevention of secondary illnesses¹². In fact, early identification of risk factors is the biggest tool in prevention of cardiovascular disease. Due to disturbances within the nervous system, cardiovascular events and impending symptoms can often be silent and death can ensue without any previous indication. A study completed by Bauman et al.(1994), investigated the atherosclerotic burden of 20 middle aged asymptomatic men with chronic SCI. The atherosclerotic disease was explored using thallium stress tests. Out of the 20 study subjects, 13 men were found to have positive stress test results and 8 of those individuals were categorized as moderate to severe as they were found to have multi-vessel disease²⁷. A similar study explained by Orakzai et al (2007), measured the amount of coronary artery calcification using a CT scan. The study was performed on 76 men and 15 women with chronic SCI and 300 able-bodied controls. The study compared those with tetraplegia and paraplegia and controlled for age, gender, ethnicity and cardiovascular disease risk factors. The coronary artery calcium levels were significantly higher ($p=0.001$) in the SCI population than the general population. Furthermore, men were found to have significantly more calcium deposits than the women observed in the study with $P=0.01$. Tetraplegia was once again found to have a higher atherosclerotic burden than those with paraplegia was 13.6% of tetraplegics and 6.4% of paraplegics

were found to have high coronary artery calcium deposits. When analyzed further, those with high coronary artery calcium deposits on average had been injured for over 10 years and were an average age of 49 years old¹⁵.

As the primary provider of an individual with SCI, one must be hyper-aware of the cardiovascular risk factors at a younger age than the general population. Whether it is body composition changes leading to obesity, glucose intolerance, dyslipidemia, hypertension, osteoporosis, or smoking, identification is key to prevention. The longer the individual is exposed to the risk factor and the more abundant the risk factors are, the stronger the relationship with developing a secondary illness¹⁸. Highlighting the importance of a decreased caloric intake and increasing physical activity as much as one can tolerate can help to decrease adverse health events^{12,18}. Many of the diets to recommend to patients include low carbohydrate and fat intake and these dietary changes must be kept indefinitely¹⁸.

Psychosocial well-being

Contrary to the numerous physical risk factors that can be identified and related to secondary illnesses in those with chronic SCI, psychological health remains a key factor in one's health and well-being. Observations of the general population show independence and self-worth increase as aging occurs. While this remains possible for those with a SCI, 20% of this population report a decreased perception of self-worth as the aging process occurs. Depression often coexists with age related health concerns as one becomes more dependent upon others for daily life activities. These individuals were

also noted to have a worse perception of their individual health status and would often seclude themselves from society. They may also be at higher risk for participating in hazardous and possible life-threatening activities including alcohol, smoking and overuse of medications¹².

According to Bombardier et al., the Patient Health Questionnaire used to determine mental health of patient's with SCI shows the highest rate and most severe depression occurs in those ages 25-49 years old. When compared to the general population, those with a spinal cord injury for >10 years have a significantly higher rate of depression with rates upwards of 33% or higher when co-morbidities are present. The rate of depression is often highest for the two decades following spinal cord injury due to decreased independence, increased dependence on caregivers and a feeling of being lost in society¹². Providers should also be cognizant of possible Post-Traumatic Stress Disorder (PTSD). In a retrospective study completed by Schöenberg et al. (2014), 8.8% of patients were diagnosed with PTSD upon discharge from the hospital and 2% were diagnosed with chronic PTSD from the sustained injury. The diagnosis of PTSD was found to be strongly associated ($r=0.60$) with the level of depression the patient experienced. Though this specific study was able to illustrate the presence of PTSD in SCI patients, existing studies show a sizeable range of results with no clarity as to the percentage of patient's affected by PTSD and at what point in time screening should occur. Currently recommendations for providers include screening all SCI patients of all stages of the disease process. This is significant for both the acute and chronic settings as fluctuations in independence and health status correlate to the severity of depression²⁸.

In many cases, the amount of hope for regaining function is directly proportionate to an individual's well-being and happiness. This becomes infinitely important as a provider to be able to gauge the patient's happiness and overall goals of care. It may come to a point where the patient may need to further discuss this topic with psychologist who focus on goals and expectations of the rehabilitation process when living with a SCI²⁹.

Individuals who face every day with a spinal cord injury require congruity in their complex care rather than further fragmentation. Fragmentation and hand off of care can further exacerbate mental and physical health disparities. At a basic level, the more spread out one's care is, the harder it is for the individual to make each appointment or even force a decision to be made between rehabilitation and medical care¹². Many individuals with a spinal cord injury are dependent upon caregivers, cannot drive to their appointments and lack the monetary means. Similar to the general public, low income is one of the forecasters of morbidity and mortality in the SCI population³⁰. It is for this reason John Young, MD developed a study to investigate the advantages of holistic and comprehensive care versus the precedent of fragmented care. His research suggesting the superiority of comprehensive care supported the development of Spinal Cord Injury Model Systems (SCIMS). SCIMS designated one regional comprehensive center for patients to attend and receive all of their care. On a larger scale, accredited SCIMS centers throughout the United States allow for a sharing of data that encourages further research and more precise analysis of the SCI population³¹. Recently, SCIMS have fallen

out of practice creating higher levels disjointed care and smaller amounts of data available to evaluate and potentially benefit the SCI population.

By developing a stronger knowledge base for primary care and rehabilitative providers there can be a more coordinated approach to each patient's care therefore improving quality of life, psychosocial and physical well-being.

METHODS

Study Design

This curriculum proposal titled “Long-term Health Consequences of Chronic Spinal Cord Injury” will be a Continued Medical Education (CME) for primary healthcare providers; Physicians, Physician Assistants and Nurse Practitioners. After completing the 1-hour seminar and successfully scoring an 80% on the post-test, providers will be given 1 credit of CME. This curriculum will be presented to providers attending national CME conferences. The program will be an informational overview of the most pertinent long-term sequelae for patients with spinal cord injuries and how to risk stratify these patients to prevent secondary illness. Recent studies show the importance of early detection and modification of sedentary lifestyle, obesity and disease processes to prevent skin breakdown, fractures, dyslipidemia, diabetes, and cardiovascular events in those with SCIs.

Study population and sampling

This CME credit curriculum will be available as an educational seminar for primary healthcare providers attending national CME conferences. The educational curriculum will be available as CME credit at national conferences held by the American Academy of Family Physicians (AAFP), American Academy of Physician Assistants (AAPA) as well as the American Association of Nurse Practitioners (AANP). The predicted sample size will be a total of 50 healthcare providers, 15 from each respective provider groups.

The course will be available to providers of all specialties but it will be geared towards Primary Care Providers, as these individuals are more likely to comprehensively oversee and manage care of patients with spinal cord injuries. The goal of providing three different types of healthcare providers with information regarding long-term health consequences of SCI will expectantly improve overall wellness and patient satisfaction.

Recruitment

Recruitment will be based upon healthcare provider self-selection. All Physicians, Physician Assistants and Nurse Practitioners attending the conference will be included. This educational seminar will be announced on the AAFP, AAPA, AANP websites promoting their national conferences with an online web link to sign up for the course. The providers will also have the opportunity to sign up for the seminar at the national conference if they did not previously register online.

Curriculum

This educational curriculum will be structured as an hour-long PowerPoint presentation regarding the current research in the field of spinal cord injuries. The program will be an informational overview of the most pertinent long-term sequelae for patients with spinal cord injuries and how to risk stratify these patients to prevent secondary illness. Recent studies show the importance of early detection and modification of sedentary lifestyle, obesity and disease processes to prevent skin breakdown, fractures, hypercholesterolemia, diabetes, and cardiovascular events. The lecture will discuss

patients at risk for spinal cord injury, epidemiology of SCI, along with the stated learning objectives. This curriculum will be presented to providers attending national CME conferences.

Table 5: Learning Objectives for CME Conferences

At the end of the education session, the Physician, Physician Assistant and Nurse Practitioner will be able to:
1. Assess and manage changes in body habitus due to sedentary life
2. Recognize risk factors for pressure ulcers and appropriately intervene
3. Evaluate risk factors for osteoporosis-related fractures and appropriately intervene
4. Evaluate risk factors for cardiovascular event and appropriately intervene
5. Evaluate risk for atherosclerotic disease and whether use of statin is appropriate.
6. Determine the patient's level of physical activity and whether cardiac rehabilitation or modern treatments may be appropriate to decrease risk of cardiovascular disease

Curriculum Assessment

The curriculum will be assessed based on the pre and post-test results from the providers that attend the course. The pre-test will provide a reference of the provider's understanding of the lifetime health consequences of SCI. The post-test will detect the knowledge gained during the course.

An informational questionnaire will be available at the end of the session to gauge provider willingness to implement in their every day practice, what type of provider they are, where they practice and what specialty field they practice in.

Study Variables and Measures:

An identical 10-question test will be implemented prior to the start of the course and repeated after concluding the lecture. The test will consist of questions from the six stated learning objectives as well as the following concepts:

- Epidemiology of SCI
- Glucose intolerance in SCI population
- Depression rates in SCI population
- Benefit of comprehensive care and SCIMS

Provider demographics will be gathered using an informational questionnaire

- Type of the provider
 - Physician
 - Physician Assistant
 - Nurse Practitioner
- Location of current practice
- Specialty field of current practice
- Number of current SCI patients under the provider's care
- Likelihood of implementing information gained during CME into daily practice
 - Scale 0-5; 0 = Very unlikely and 5 = Very likely

Data Collection

The proposed CME course will be implemented in 2018 at the respective AAFP, AAPA and AANP national conferences. An identical 10-question clicker examination will be

implemented at the beginning and the end of the educational sessions to test the Primary Healthcare Provider's knowledge. Clickers will be handed out at the beginning of the session and the number on the clicker will become the PA's identifier to monitor test results. Each positively stemmed test question will have five answer options with one correct answer. Each respective test will be 10 minutes long. In order to appropriately collect data on the providers attending the course, the post-test will be administered immediately after the lecture ends. This method will allow for individual scores to be computed using the same clicker identification and decreases the chance of provider's lost to follow up if the post-test were given at a later date via email.

Topics to be covered in the exam relate to the stated learning objectives; epidemiology of SCI, who is at highest risk for SCI, pressure ulcers, fracture risk, atherosclerosis, statin use, risk of cardiovascular event, physical activity requirements and the effect on mental health.

Data Analysis

A paired t-test will be used to measure the effectiveness of CME curriculum. The paired t-test will compare the respective mean scores from the pre and post-tests.

Additionally, each individual provider must pass the post-test with 80% in order to earn the 1 credit of CME.

Timeline and resources

The CME curriculum will need to be approved by the AAFP, AAPA, AANP administrations in order to be approved and recognized as a CME. After CME approval occurs, the course will be announced on each of the respective organization's CME training website. The provider's will self-select the conference course. The proposed courses will plan to be implemented at the 2018 national conferences.

Resources necessary to support this educational curriculum include travel accommodations for the lecturer and support staff. At the conference, the lecture hall will need to be reserved for 1.5 hours and multimedia support will be required to accommodate the course. Clickers will need to be obtained for each provider attending the seminar. Funding will be required to support the conferences. Once the data has been obtained, a statistician will be required for data analysis.

Institutional Review Board

The proposed study design is a CME seminar that compares the efficacy of an educational curriculum with an aim to benefit the development of healthcare. According to Boston University IRB policies and procedures, the proposal meets criteria to qualify as exempt of human research. The proposal will be submitted as an Exempt Application to Boston University's IRB under the 45 CFR 46.101(b) regulation.

CONCLUSION

Discussion

Medicine has evolved to become an evidence-based model; yet, the field of spinal cord injury research is lacking screening methods and guidelines for the primary healthcare providers to deliver comprehensive care. By creating CME seminars for Physicians, PAs and NPs about the current understanding of health consequences in chronic spinal cord injuries, the current best practices will be documented. Education is the first step in advancing care for patient's living with a spinal cord injury.

The self-selective method of the CME allows for provider's interested in the topic to attend the course and ideally create a higher level of successful implementation of these concepts into their daily practice. Allowing self-selection at national conferences may also increase the diversity of provider specialties, demographics and patient populations. Providing 1 CME credit for the course may also increase incentive for healthcare providers to attend the seminar.

The goal of the proposed CME is to educate healthcare providers of the secondary health consequences with chronic spinal cord injury. Limitations of this proposal include a shortage of comprehensive data. There is a general understanding that secondary disease processes including osteoporotic fractures, diabetes, dyslipidemia and cardiovascular disease prematurely arise; yet specific screening tools and therapy guidelines are unclear. There is a demand for longitudinal studies that follow a large cohort of SCI patients of all ages and demographics from time of injury to death in order

to establish a better understanding of the long-term sequelae of disease processes that ensue following SCI.

Summary

Spinal cord injuries are devastating and life-altering incidents affecting one's independence, psychosocial well-being and overall bodily function. In the United States there is an evolving bimodal age distribution made up of young males and elderly individuals that are most often affected by spinal cord injuries. The increase in elderly population enduring SCIs has increased the number and rate at which comorbid risk factors develop.

The involuntary sedentary lifestyle and interruption in nerve innervation causes an increase in adiposity and decrease in lean tissue mass, thus cultivating metabolic and endocrine dysfunction such as diabetes and dyslipidemia. There is an additional increased risk of developing pressure sores, osteoporosis and infections. As the risk factors accumulate, cardiovascular and pulmonary events ensue and become the leading causes of death in the SCI population.

There are documented guidelines demonstrating treatments for able-bodied individuals with osteoporosis, diabetes, hypertension, dyslipidemia, atherosclerotic coronary artery disease and more. However, the current medical model fails to establish guidelines for treating the secondary SCI sequelae described herewith. The SCI population is a unique subset of individuals that are at an overall increased and premature risk of death from infectious, pulmonary and cardiovascular etiologies. This CME

proposal endeavors to bring awareness to primary healthcare providers regarding the identifiable risk factors and deliver insight as to how to best manage patients with chronic SCI. As research regarding treating long-term chronic SCI is in beginning stages, the individualized and centralized care begins with the primary healthcare providers. The primary provider will have the capability to oversee and ultimately manage the patient's care. Subsequently, the greater the awareness of these secondary health consequences, the greater the demand for further studies to advance the field.

Clinical and/or public health significance

Due to an increase in medical understanding and technology, a larger number of patients are surviving the acute phase and living chronically with a SCI. However, the SCI community continues to be burdened with morbid complications and reduced lifespans compared to the general public. This escalates the obligation for provider education as quality of life and lifespans remain suppressed. The goal of creating preventative and therapeutic management guidelines for healthcare providers around the United States will ideally improve overall care, patient-provider relationships, quality of life, and the longevity of life in the SCI population.

APPENDIX 1

CME CONFERENCE SYLLABUS

PowerPoint Syllabus

- Epidemiology
- Who is at risk for SCI
 - Age
 - Gender
- Trends in life expectancy
- Sedentary lifestyle
- Osteoporotic fracture risk
- Prevention of pressure sores
- Diminished symptoms of infection
- Changes to body habitus
 - Decrease in lean muscle
 - Increase in adiposity
- BMI Adjustments
- Metabolic dysfunction
- Diabetes
- Blood pressure dysregulation
- Dyslipidemia
- Atherosclerotic disease
 - Tetraplegia versus paraplegia
- Risk of cardiovascular event
- Lifestyle modifications
- Exercise regimen
- Statin use for dyslipidemia
- Psychological well-being
- Comprehensive care

LIST OF JOURNAL ABBREVIATIONS

Am J Phys Med Rehabil	American Journal of Physical Medicine & Rehabilitation
Arch Phys Med Rehabil	Archives of Physical Medicine and Rehabilitation
Cochrane Database Syst Rev	The Cochrane Database of Systematic Reviews
Eur J Clin Nutr	European Journal of Clinical Nutrition
Int J Behav Med	International Journal of Behavioral Medicine
J Appl Physiol	Journal of Applied Physiology
JB Libr Syst Rev	JB Libr Library of Systematic Reviews
J Med Life	Journal of Medicine and Life
J Spinal Cord Med	The Journal of Spinal Cord Medicine
Metabolism	Metabolism: Clinical and Experimental
Neural Regen Res	Neural Regeneration Research
Osteoporos Int	Osteoporosis International
Respir Physiol Neurobiol	Respiratory Physiology & Neurobiology

REFERENCES

1. Spinal Cord Injury Information Page: National Institute of Neurological Disorders and Stroke (NINDS).
<http://www.ninds.nih.gov/disorders/sci/sci.htm>. Accessed August 17, 2016.
2. Krassioukov A. Autonomic function following cervical spinal cord injury. *Respir Physiol Neurobiol.* 2009;169(2):157-164. doi:10.1016/j.resp.2009.08.003.
3. Spinal Cord Research & Education - Paralyzed Veterans of America.
http://www.pva.org/site/c.ajlRK9NJLcJ2E/b.6305817/k.3A08/Spinal_Cord_Research_Education.htm. Accessed August 17, 2016.
4. Stillman MD, Aston CE, Rabadi MH. Mortality benefit of statin use in traumatic spinal cord injury: a retrospective analysis. *Spinal Cord.* 2016;54(4):298-302. doi:10.1038/sc.2015.180.
5. Partida E, Mironets E, Hou S, Tom V. Cardiovascular dysfunction following spinal cord injury. *Neural Regen Res.* 2016;11(2):189. doi:10.4103/1673-5374.177707.
6. Osterthun R, Post MWM, van Asbeck FWA, van Leeuwen CMC, van Koppenhagen CF. Causes of death following spinal cord injury during inpatient rehabilitation and the first five years after discharge. A Dutch cohort study. *Spinal Cord.* 2014;52(6):483-488. doi:10.1038/sc.2014.28.
7. Köseoğlu BF, Safer VB, Öken Ö, Akselim S. Cardiovascular disease risk in people with spinal cord injury: is there a possible association between reduced lung function and increased risk of diabetes and hypertension? *Spinal Cord.* July 2016. doi:10.1038/sc.2016.101.
8. Garshick E, Kelley A, Cohen SA, et al. A prospective assessment of mortality in chronic spinal cord injury. *Spinal Cord.* 2005;43(7):408-416. doi:10.1038/sj.sc.3101729.
9. Grigorean VT, Sandu AM, Popescu M, et al. Cardiac dysfunctions following spinal cord injury. *J Med Life.* 2009;2(2):133.
10. College O. *English: Illustration from Anatomy & Physiology, Connexions Web Site.* [Http://Cnx.org/Content/col11496/1.6/, Jun 19, 2013.](Http://Cnx.org/Content/col11496/1.6/, Jun 19, 2013.;); 2013.
https://commons.wikimedia.org/wiki/File:715_Vertebral_Column.jpg. Accessed January 6, 2017.
11. DeVivo MJ. Epidemiology of traumatic spinal cord injury: trends and future implications. *Spinal Cord.* 2012;50(5):365-372. doi:10.1038/sc.2011.178.

12. Groah SL, Charlifue S, Tate D, et al. Spinal Cord Injury and Aging: Challenges and Recommendations for Future Research. *Am J Phys Med Rehabil.* 2012;91(1):80-93. doi:10.1097/PHM.0b013e31821f70bc.
13. Cameron ID, Gillespie LD, Robertson MC, et al. Interventions for preventing falls in older people in care facilities and hospitals. *Cochrane Database Syst Rev.* 2012;12:CD005465. doi:10.1002/14651858.CD005465.pub3.
14. Stern C, Jayasekara R. Interventions to reduce the incidence of falls in older adult patients in acute care hospitals: a systematic review. *JBI Libr Syst Rev.* 2009;7(21):942-974.
15. Orakzai SH, Orakzai RH, Ahmadi N, et al. Measurement of coronary artery calcification by electron beam computerized tomography in persons with chronic spinal cord injury: evidence for increased atherosclerotic burden. *Spinal Cord.* 2007;45(12):775-779. doi:10.1038/sj.sc.3102045.
16. Bethel M, Weaver FM, Bailey L, et al. Risk factors for osteoporotic fractures in persons with spinal cord injuries and disorders. *Osteoporos Int.* 2016;27(10):3011-3021. doi:10.1007/s00198-016-3627-2.
17. Zanca JM, Heyn P, Horn S, et al. Evaluating Your Pressure Ulcer Prevention Plan: A problem-solving worksheet for people with spinal cord injury and their health care providers. *Arch Phys Med Rehabil.* 2015;96(11):2089-2090. doi:10.1016/j.apmr.2015.03.001.
18. Bauman WA, Spungen AM. Coronary heart disease in individuals with spinal cord injury: assessment of risk factors. *Spinal Cord.* 2008;46(7):466-476. doi:10.1038/sj.sc.3102161.
19. Nuhlicek DN, Spurr GB, Barboriak JJ, Rooney CB, el Ghatit AZ, Bongard RD. Body composition of patients with spinal cord injury. *Eur J Clin Nutr.* 1988;42(9):765-773.
20. Spungen AM, Wang J, Pierson RN, Bauman WA. Soft tissue body composition differences in monozygotic twins discordant for spinal cord injury. *J Appl Physiol Bethesda Md 1985.* 2000;88(4):1310-1315.
21. Dionyssiotis Y, Mavrogenis A, Trovas G, Papathanasiou J, Papegelopoulos P. Bone And Soft Tissue Changes In Patients With Spinal Cord Injury And Multiple Sclerosis : *Folia Medica.*
<https://www.degruyter.com/view/j/folmed.2014.56.issue-4/folmed-2015-0002/folmed-2015-0002.xml>. Published December 1, 2014. Accessed November 11, 2016.

22. Chopra AS, Miyatani M, Craven BC. Cardiovascular disease risk in individuals with chronic spinal cord injury: Prevalence of untreated risk factors and poor adherence to treatment guidelines. *J Spinal Cord Med*. 2016;0(0):1-8. doi:10.1080/10790268.2016.1140390.
23. Whiteneck GG, Charlifue SW, Frankel HL, et al. Mortality, morbidity, and psychosocial outcomes of persons spinal cord injured more than 20 years ago. *Paraplegia*. 1992;30(9):617-630. doi:10.1038/sc.1992.124.
24. Bauman WA, Spungen AM. Disorders of carbohydrate and lipid metabolism in veterans with paraplegia or quadriplegia: a model of premature aging. *Metabolism*. 1994;43(6):749-756.
25. Nash MS, Kressler J. Model Programs to Address Obesity and Cardiometabolic Disease: Interventions for Suboptimal Nutrition and Sedentary Lifestyles. *Arch Phys Med Rehabil*. 2016;97(9, Supplement):S238-S246. doi:10.1016/j.apmr.2016.05.026.
26. Totosy de Zepetnek JO, Pelletier CA, Hicks AL, MacDonald MJ. Following the Physical Activity Guidelines for Adults With Spinal Cord Injury for 16 Weeks Does Not Improve Vascular Health: A Randomized Controlled Trial. *Arch Phys Med Rehabil*. 2015;96(9):1566-1575. doi:10.1016/j.apmr.2015.05.019.
27. Bauman WA, Raza M, Spungen AM, Machac J. Cardiac stress testing with thallium-201 imaging reveals silent ischemia in individuals with paraplegia. *Arch Phys Med Rehabil*. 1994;75(9):946-950.
28. Schoenenberg M, Reimitz M, Jusyte A, Maier D, Badke A, Hautzinger M. Depression, Posttraumatic Stress, and Risk Factors Following Spinal Cord Injury. *Int J Behav Med*. 2014;21(1):169-176. doi:10.1007/s12529-012-9284-8.
29. Pretz CR, Kozlowski AJ, Chen Y, Charlifue S, Heinemann AW. Trajectories of Life Satisfaction After Spinal Cord Injury. *Arch Phys Med Rehabil*. 2016;97(10):1706-1713.e1. doi:10.1016/j.apmr.2016.04.022.
30. Krause JS, Cao Y, DeVivo MJ, DiPiro ND. Risk and Protective Factors for Cause-Specific Mortality after Spinal Cord Injury. *Arch Phys Med Rehabil*. doi:10.1016/j.apmr.2016.07.001.
31. Chen Y, DeVivo MJ, Richards JS, SanAgustin TB. Spinal Cord Injury Model Systems: Review of Program and National Database From 1970 to 2015. *Arch Phys Med Rehabil*. 2016;97(10):1797-1804. doi:10.1016/j.apmr.2016.02.027.

CURRICULUM VITAE

