Cardiovascular Health and Exercise Following Spinal Cord Injury

Executive Summary

What Cardiovascular problems occur after injury?
There is considerable evidence indicating an earlier onset and/or prevalence of various chronic diseases (including Cardiovascular disease (CVD), type II diabetes, and osteoporosis) in persons with SCI [1,2,3,4,5,6,7]. Similar to people without SCI, physical inactivity plays a significant role in the risk for CVD in people with SCI. In fact, the ordinary activities of daily living do not appear to be sufficient to maintain cardiovascular fitness in persons with SCI. Moreover, extremely low levels of physical activity and fitness may lead to a vicious cycle of further decline. Ultimately these changes will have significant implications for the development of CVD (and associated co-morbidities) and the ability to live an independent and healthy lifestyle.

How common are Cardiovascular problems after Spinal Cord Injury?
CVD is a leading cause of mortality in both able-bodied individuals and persons with SCI [2]. The prevalence rate of symptomatic CVD in SCI is 30–50% in comparison to 5%–10% in the general able-bodied population [8]. Moreover, the prevalence of asymptomatic CVD has been estimated to be 60%–70% in persons with SCI [9,10]. It also appears that persons with SCI have increased CVD-related mortality rates and those with tetraplegia experience mortality at earlier ages in comparison to able-bodied individuals [2,8,11]. These are alarming statistics, which place a significant burden upon the person with SCI, his/her family, and society as a whole.

What are the risk factors for Cardiovascular problems?
Lesion Level
Cardiac function is strongly influenced by the lesion level; individuals with a T1 lesion will not have any supraspinal sympathetic control, those with a T1-T5 lesion will have partial preservation, while those with an injury below T5 will have full supraspinal sympathetic control of the heart and upper body vasculature [12]. Adrenergic dysfunction, poor diet, and physical inactivity are thought to play key roles in the elevated risk for CVD in SCI [7,13].

Physical Inactivity and Deconditioning
Physical inactivity is a major independent risk factor for CVD and premature mortality in persons with SCI [14,15]. Unfortunately, physical inactivity is highly prevalent among persons with SCI and ordinary activities of daily living are not adequate to maintain cardiovascular fitness [16,17]. Marked inactivity associated with SCI has been associated with lower high-density lipoprotein (HDL) cholesterol [18,19] elevated low-density lipoprotein (LDL) cholesterol[18]; triglycerides[18, 19]; total cholesterol levels[18]; abnormal glucose homeostasis[19,20]; increased adiposity [19,20]; and excessive reductions in aerobic fitness [18, 19]. Moreover, a reduction in cardiovascular fitness may also lead to a vicious cycle of further decline leading to a reduction in functional capacity and the ability to live an independent lifestyle.

What management options are there for Cardiovascular problems?
Based on preliminary evidence (primarily level 4), it would appear that various exercise modalities (including arm ergometry, resistance training, BWSTT, and FES) may attenuate and/or reverse abnormalities in glucose homeostasis, lipid lipoprotein profiles, and cardiovascular fitness. As such, exercise training appears to be important for reducing the risk for CVD and multiple comorbidities (such as type 2 diabetes, hypertension, and obesity) in individuals with SCI. However, there is little research on SCI in comparison to the general population and other clinical conditions (e.g. chronic heart failure [14,15]. The previously mentioned physical inactivity and deconditioning have important clinical implications for exercise progression, *as the starting workload may need to be low* (e.g.,

submaximal and performed in bouts with rest in between) and customized to progress slowly due to issues of fatigue, as well as exercise-induced hypotension [21].

Non-Pharmacological Options

Aerobic Exercise and Treadmill Training

A common method of aerobic exercise in people with SCI is Body Weight-Supported Treadmill Training (BWSTT) – a harness and treadmill system used to provide a safe environment for stepping and gait without the fear of falling. The amount of unloading (de-weighting) can be adjusted so that the client takes anywhere from all of their weight to no weight at all, and stepping can be assisted by a physical therapist if motor control is limited. There is evidence to suggest that BWSTT can improve indicators of cardiovascular health (e.g., arterial compliance [22], cardiac autonomic balance [23], peak oxygen uptake and heart rate[24,25] in individuals with complete and incomplete SCI.

There is good evidence from several studies[26,27,28,29] to suggest that aerobic exercise training programs (performed at a moderate-to-vigorous intensity 20–30 min/day, three days/week for eight weeks) are effective in improving the lipid lipoprotein profiles of persons with SCI. The optimal training program for changes in lipid lipoprotein profile remains to be determined. However, a minimal aerobic exercise intensity of 70% of HRR on most days of the week appears to be a good general recommendation for improving lipid lipoprotein profile.

Upper Extremity Exercise

If moving the legs is difficult, there is research indicating that upper extremity exercise (e.g., arm cycle ergometry) at a moderate-to-vigorous intensity, three days/week for at least six weeks, improves cardiovascular fitness and exercise tolerance in persons with SCI. The optimal exercise intervention for improving cardiovascular fitness remains to be determined. There is also evidence[27] that high-intensity (70%–80% HRR) exercise can lead to greater improvements in peak power and $VO2_{peak}$ than low-intensity (50%–60% HRR) exercise. There is also evidence to suggest that resistance training at a moderate intensity for at least two days/week also appears to be appropriate for the rehabilitation of persons with SCI [30,31,32,33].

Functional Electrical Stimulation (FES)

There is growing evidence from multiple pre-post studies [34,35,36,37,38,39,40,41,42] that FES training performed for a minimum of three days per week for two months may be effective for improving musculoskeletal fitness, the oxidative potential of muscle, exercise tolerance, and cardiovascular fitness. Gait training and Neuromuscular electrical stimulation can also increase metabolic and cardiorespiratory response in persons with complete tetraplegia [43].

Some evidence indicates that aerobic exercise (often Gait or Treadmill training) paired with FES exercise training programs (performed 30 min/day, three days per week for eight weeks or more) are effective in improving glucose homeostasis in persons with SCI, and that the magnitude of this change is clinically significant [27,44,45,46,47].

Limitations of What We Know

The relationship between increasing physical activity and health status of SCI has not been evaluated adequately to date, particularly over the long-term. Well-designed RCTs are required in the future to establish firmly the primary mechanisms by which exercise interventions elicit these beneficial changes. Similarly, further research is required to evaluate the effects of lesion level and injury severity on exercise prescription, such that exercise programs can be developed that address the varied needs of persons with SCI. Moreover, long-term follow-up investigations are required to determine whether training-induced changes in risk factors for CVD translate directly into a reduced incidence of CVD and premature mortality in persons with SCI. Also, there is a need to determine more definitively the relationship of diet and exercise on these risk factors – can diet or exercise alone or diet and exercise together decrease these risk factors?

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