CESSATION OF BWSTT: WALKING AND HRQL IN INDIVIDUALS WITH SCI

CESSATION OF A 12-MONTH BODY-WEIGHT SUPPORTED TREADMILL TRAINING PROGRAM: EFFECT ON FUNCTIONAL AMBULATION AND HEALTH-RELATED QUALITY OF LIFE IN INDIVIDUALS WITH INCOMPLETE SPINAL CORD INJURY

By

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ABSTRACT

The purpose of this study was to determine the effects of cessation of a 12-month thrice-weekly body-weight supported treadmill training (BWSTT) program on functional ambulation and aspects of health-related quality of life (HRQL) in individuals with incomplete SCI. Twelve men and women (aged 22-55) with chronic (> 1 year post-injury) incomplete SCI (ASIA B or C) returned for follow-up (FOL) testing 37 weeks (SD 2.1) following their final scheduled BWSTT session. Functional ambulation was compared based on: *i)* required percentage of body-weight support (%BWS) on the treadmill, *ii)* preferred treadmill speed and *iii)* overground walking. Evaluation of HRQL included measures of: *i)* satisfaction with life, *ii)* perceived ability to perform activities of daily living (ADL), *iii)* perceptions of health, and *iv)* depressive symptomology. Participants were invited to participate in once-weekly BWSTT and twice-weekly fitness training during the FOL period (37 sessions); the actual number of BWSTT sessions attended was only 11.6 (range 0-29) and the total days of exercise was 29.1 (range 0-75). The 12-month BWSTT program resulted in a decrease in the required %BWS (73±10% to 19±12%; $p<.01$), an increase in treadmill speed (0.5±0.3 to 1.4±0.8 km/h; $p<.01$), improved overground walking in 4 individuals, and improved group satisfaction with life ($p<.05$). At FOL, %BWS increased to 35±14% ($p<.01$), but was still less than at pre-training ($p<.01$). There were no differences between 12-month and FOL scores on any HRQL-related measures. High exercise adherence during the FOL period had a strong correlation with a positive percent change in perceived ability to perform ADL ($r = .70$; $p<.05$), as well as non-significant trends with positive percent change in perceptions of health and negative percent change in depressive symptomology ($r = .49$; $p=.13$ and $r = -.51$; $p=.11$, respectively). Therefore, even with very limited access to the BWS treadmill, much of the improvement in treadmill walking ability and satisfaction with life following long-term BWSTT in individuals with incomplete SCI can be retained for at least 8 months. Continued exercise participation, however, may contribute to maintain or further improve aspects of HRQL in this population.

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- Remind yourself that when you die, your "in basket" won't be empty.
- Ask yourself the question: "Will this matter a year from now?"
- Surrender to the fact that life isn't fair.
- Spend a moment every day thinking of someone to thank.
- Life is a test. It is only a test.
- Be flexible with changes in your plans (definitely a grad-school must!)

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1.0 BACKGROUND

1.1 TRAUMATIC SPINAL CORD INJURY

1.1.1 Description and Classification of Traumatic Spinal Cord Injury

Traumatic spinal cord injury (SCI) describes injury to the spinal cord due to penetration of the cord by a foreign object (such as a knife) or compression of the cord by soft tissue or bony structures (as a result of non-penetrating injury to the spinal cord and/or vertebral column; Somers, 1992). Damage to the spinal cord can result in motor function (paralysis) and/or sensory (paresthesis) loss, with the extent of loss depending on the level and severity of the injury (Mariebb, 2002). The American Spinal Injury Association (ASIA) Impairment Scale (Table 1) is a widely used classification system to grade the degree of impairment following SCI based on The International Standards for Neurological and Functional Classification of Spinal Cord Injury (Maynard et al., 1997). "The most caudal segment of the spinal cord with normal sensory and motor function on both sides of the body" defines the neurological level and may differ from the skeletal level of injury (Maynard et al., 1997). Absence of sensory and motor function in the lowest sacral segment identifies a complete injury, whereas partial preservation of sensory and/or motor function below the neurological level and in the lowest sacral segment identifies an incomplete injury (Maynard et al., 1997). Injuries affecting the cervical spinal cord (tetraplegia) result in impairment of the upper and lower limbs, as well as the pelvic organs and the trunk (Maynard et al., 1997). If the thoracic, lumbar, or sacral area of the spinal cord is injured, the trunk, legs and pelvic organs incur some loss (paraplegia; Maynard et al., 1997).

Table 1: ASIA Impairment Scale (Maynard et al., 1997)

ASIA Class	Complete or Incomplete	Description
A	Complete	No sensory or motor function is preserved in the sacral segments S4-S5.
B	Incomplete	Sensory but not motor function is preserved below the neurological level and extends through the sacral segments S4-S5.
C	Incomplete	Motor function is preserved below the neurological level, and the majority of key muscles below the neurological level have a muscle grade less than 3.
D	Incomplete	Motor function is preserved below the neurological level, and the majority of key muscles below the neurological level have a muscle grade greater than or equal to 3.
E	Normal	Sensory and motor function is normal.

1.1.2 Traumatic SCI: Incidence, Prevalence, and Life Expectancy

According to the Canadian Paraplegic Association (2000), over 30,000 Canadians currently are living with a SCI (~ 35 per million population), with approximately 1050 new injuries occurring each year. The majority of the injuries in Canada are due to motor vehicle accidents (54.7%) and falls (17.7%). Of those living with a SCI, the majority were injured between the ages of 15 and 34 (78%) and are male (81%).

In the United States, the annual incidence of traumatic SCI is approximately 40 cases per million population (not including those who die at the scene of the accident), translating to 10,000 new cases each year (The National Spinal Cord Injury Association, 2001). Between 183,000 and 230,000 individuals currently are living with a SCI in the United States. The majority of the SCIs (55%) occur in individuals aged 16 to 30 with 81.7% of these individuals being male. The causes of SCI in the United States differ slightly from those in Canada, with motor vehicle accidents accounting for 37.4% and acts of violence, 25.9%.

In North America, improvements in emergency medicine have led to continued increases in life expectancy for individuals living with SCI, although it remains somewhat below that for the able-bodied (Table 2; Canadian Paraplegic Association, 2000; The National Spinal Cord Injury Association, 2001). Unfortunately, concurrent with an increase in life expectancy is an increase in the time available for the development of physical and psychosocial secondary complications (Charlifue et al., 1999).

Table 2: Life expectancy for persons who survive at least 1 year post-SCI (The National Spinal Cord Injury Association, 2001)

Age at Injury	No SCI	Motor Functional at any Level	Para	Low Tetra (C5-C8)	High Tetra (C1-C4)	Ventilator Dependent at any Level
20 yrs	57.2	52.5	46.2	41.2	37.1	26.8
40 yrs	38.4	34.3	28.7	24.5	21.2	13.7
60 yrs	21.2	18.1	13.7	10.6	8.4	4.0

1.2 SECONDARY IMPAIRMENTS ASSOCIATED WITH SCI

No matter the level or severity, SCI causes a wide spectrum of medical complications affecting organ systems above and below the level of the injury (Figure 1; Somers, 1992; Yu, 1998). Of these, the most obvious and, often, life-altering is the decrease in the ability to walk (Subbarao, 1991).

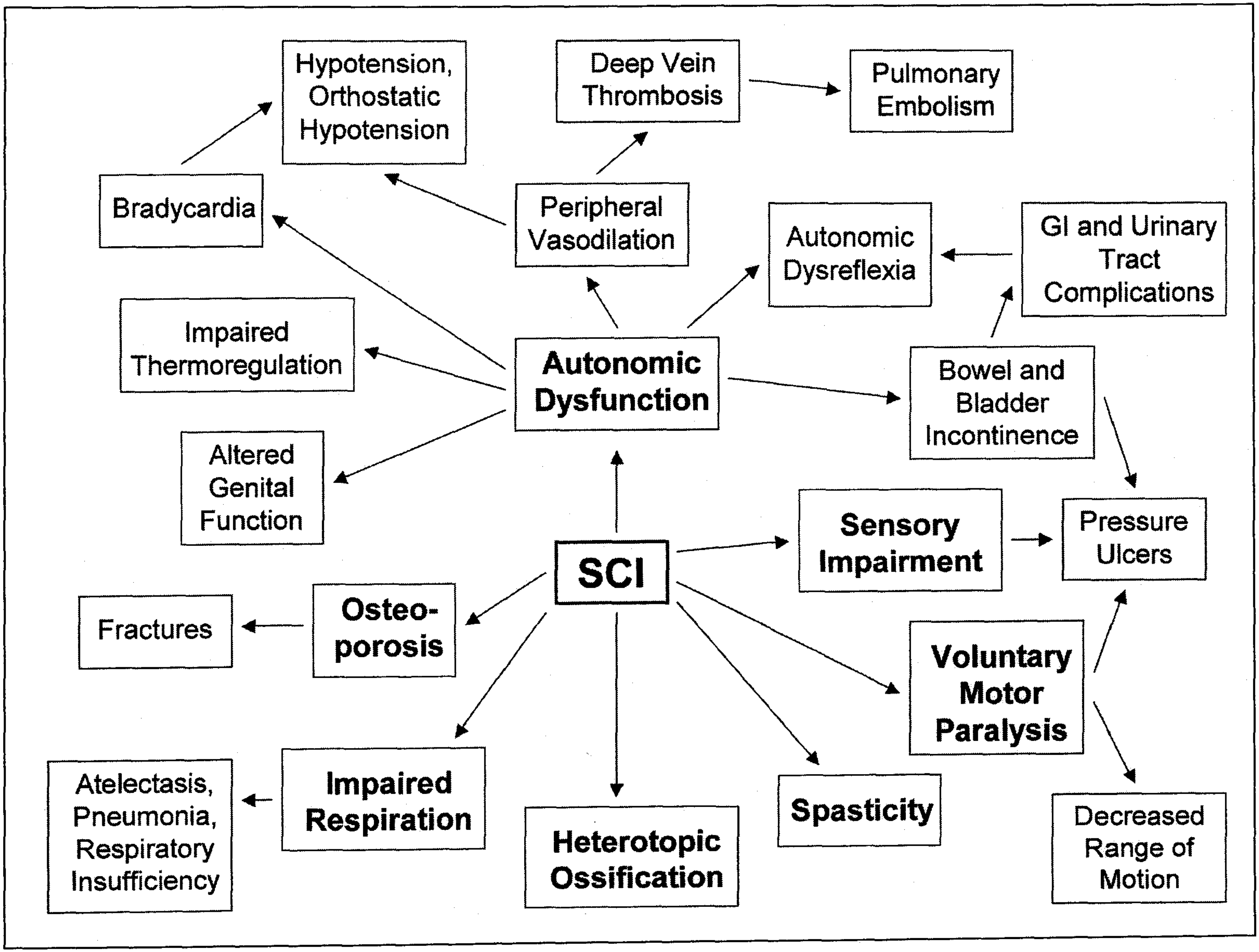


Figure 1: Schematic representation of the physical effects of spinal cord injury (Somers, 1992).

1.2.1 Decrements in Functional Ambulation: Physiology

Detailed descriptions of the neurophathology of SCI have been published (McDonald and Sadowsky, 2002; Somers, 1992). Briefly, following mechanical trauma to the spinal cord, there is direct compression of elements of the central and peripheral nervous system, injury to blood vessels, disruption of axons, and disruption of neural cell membranes. Within a short period of time, swelling of the spinal cord occurs until it fills the entire diameter of the spinal canal at the level of injury. Initial mechanical damage is then compounded by a secondary injury cascade which is triggered by ischemia, release of toxic chemicals from disrupted neural membranes, and electrolyte shifts. A flood of glutamate out of damaged spinal neurons, axons, and astrocytes is believed to overexcite neighbouring cells, causing them to let in let in waves of calcium ions, which then triggers production of free radicals. The free radicals are thought to kill healthy neurons and oligodendrocytes, resulting in the demyelination of axons and, hence, an inability to conduct impulses by unsevered axons. Even days or weeks following initial trauma, oligodendrocytes can undergo apoptosis (cell suicide) as many as four segments from the site of injury (McDonald and Sadowsky, 2002; Somers, 1992).

Once neurons are damaged, their axons are not capable of regeneration (Pearson, 2001). If damage occurs to descending motor tracts, anterior horn cells, or spinal nerves, control over the trunk and extremities is lost; as a result, the ability of an individual with SCI to execute movements with body segments below the injury level is affected (Somers, 1992). In a complete SCI (ASIA A), the area of the body below the lesion can no longer communicate with the brain, causing complete disruption of control of the systems below the lesion (Somers, 1992). In incomplete SCI (ASIA B-D), however, some motor and/or sensory pathways have remained viable, possibly including the descending motor control pathways responsible for the ability to ambulate (in ASIA C and D; Crozier et al., 1991). The degree, quality, and "functionality" of ambulation following SCI are affected by a number of factors, including hyperactive spinal reflexes (spasticity), alterations in the muscle activation patterns (weakness, motor dyscoordination), and postural problems (weight bearing, balance, propulsion; Barbeau et al., 1999; Krawtz and Nance, 1996). According to Subbarao (1991), "less than a third of patients walk again after a spinal cord injury, whereas every one of them wants to try". As a result, SCI undeniably causes changes to an individual's life which can be so profound that there is a decrease in the quality of life.

1.2.2 Quality of Life

The term quality of life (QOL) is used to define "both subjective and objective evaluations of the 'goodness' of one's life overall, and the goodness of all of the various domains that make up one's life" (Lox et al., 2003) and was first introduced in the 1950's as a political slogan (Dijkers, 1996). Early uses of the term "QOL" referred to goodness of life of the American population as a whole and included various environmental and social factors, such as "education, concern for the individual, economic growth, health and welfare, and the defense of the free world" (Flanagan, 1982). The measurement of QOL in *individuals* began in the 1970's and has continued with the realization by healthcare researchers of the importance of evaluating outcomes that are of direct relevance to the goodness of the patient's life (Dijkers, 1996).

The QOL dimensions that can be influenced by health and by health interventions are distinguished collectively under the term 'health-related quality of life' (HRQL; Lox et al., 2003). When measuring HRQL, there are broad, core dimensions that should be considered: 1) physical functioning and self-concept, 2) emotional functioning and well-being, 3) social functioning and ability to fulfill social roles, 4) cognitive functioning, 5) health status, and, in some populations, 6) sexual functioning and intimacy, and 7) work productivity (Lox et al., 2003; Rejeski et al., 1996). Objective measures (made by someone other than the individual) and subjective measures (the individual's own perceptions) of the dimensions that constitute HRQL have been shown to produce different results (Rejeski et al., 1996). For example, it is common for individuals to be dissatisfied with abilities that would otherwise meet criteria for adequate functioning defined by the medical community or to believe themselves to be more or less competent than they really are (Rejeski et al., 1996). Therefore, the importance of measuring HRQL *subjectively* is becoming more apparent; with the increasing number of people living with chronic diseases and injury sequelae for which there are no cures (e.g., stroke, arthritis, and spinal cord injuries; Rejeski et al., 1996), HRQL as perceived by the patient is as important (if not more) when evaluating the success of an intervention as is the evaluation of physiological benefits (Boswell et al., 1998; Dijkers, 1996; Fuhrer, 1994; Lox et al., 2003). If the costs associated with the intervention (e.g., negative physiological or psychological side-effects) are greater than the benefits as perceived by researchers or physicians, the intervention may actually be *decreasing* overall HRQL; without acquiring the perspective of the patient, this may go unnoticed.

1.2.2.1 Effect of SCI on Satisfaction With Life

Satisfaction with life, defined as the cognitive-judgemental aspect of the subjective component of QOL (or of HRQL), captures the reaction of an individual to "a comparison of one's life circumstances with what is thought to be an appropriate standard" (Diener et al., 1985). Changes in physical, psychological, and/or social functioning as a result of traumatic SCI undoubtedly have the potential to have a negative impact on overall life satisfaction (Figure 2; Dijkers, 1999; Noreau and Shepard, 1995; Putzke et al., 2002; Wood-Dauphinee and Küchler, 1992). Furthermore, since SCI is usually incurred at an early age and since the life expectancy of individuals with SCI is increasing (Canadian Paraplegic Association, 2003), it is possible for some individuals with SCI to have a long life, but with below average life satisfaction.

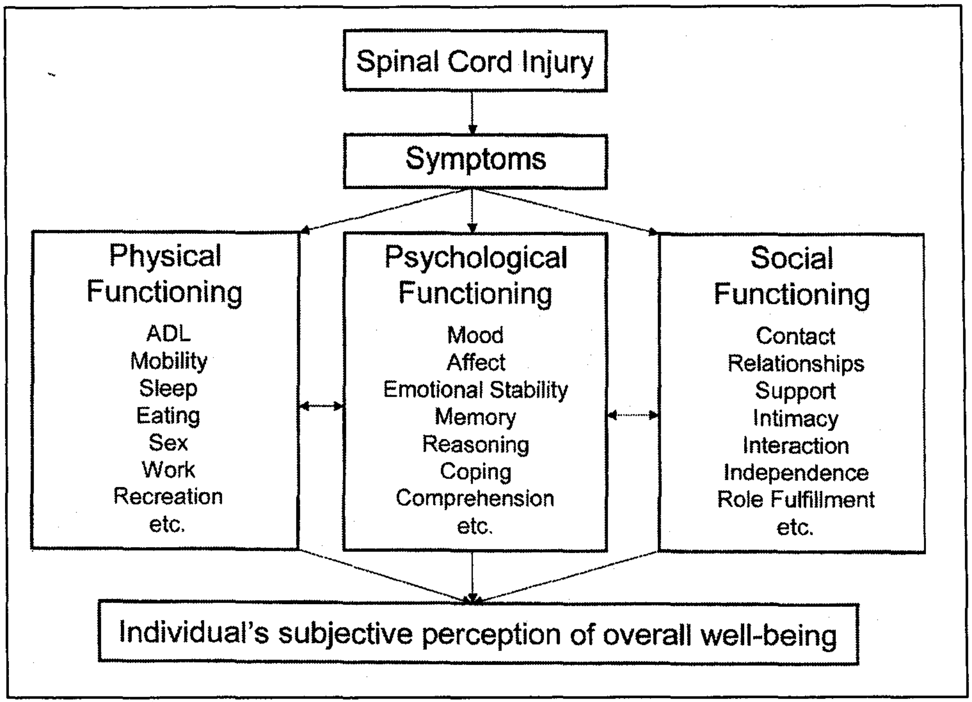


Figure 2: Effect of SCI on satisfaction with life (Wood-Dauphinee and Küchler, 1992)

According to Dijkers (1996), the study of subjective evaluations of global or domain-specific QOL in individuals with SCI is in its infancy. A study by Crewe in 1980 was the first; findings included lower life satisfaction in individuals with SCI compared to non-disabled individuals, especially in satisfaction with employment and sexual relations with spouse. Since 1980, numerous investigators have replicated the finding of lower satisfaction with life in individuals with SCI compared to a matched group or compared to the population at large (Boschen, 1990; Decker and Schultz, 1985; Dijkers, 1997; 1999; Fuhrer et al., 1992; Kreuter et al., 1998; Lundqvist et al., 1991; Schulz and Decker, 1985). It has been emphasized, however, that these overall findings of lower satisfaction with life do not indicate that every person with an SCI has decreased life satisfaction (Fuhrer et al., 1992). Important, therefore, is the identification of factors that are reliably related to decreased life satisfaction so that those at risk can be identified and rehabilitation measures that target these factors can be developed (Fuhrer et al., 1992).

Even very recently, it has been suggested that our knowledge of the overall determinants of HRQL for individuals with SCI is limited (Dijkers, 1997; Krause, 1998; Manns and Chad, 2001). Numerous approaches have been taken by investigators wishing to elucidate determinants of satisfaction with life in individuals with SCI, including semi-structured interviews (e.g., Manns and Chad, 2001), correlational and/or regression analysis studies with demographic measures (e.g., Post et al., 1998a), objective factors (e.g., Fuhrer et al., 1992), and/or subjective factors (e.g., Fuhrer et al., 1992), longitudinal investigations (e.g., Putzke et al., 2002), and meta-analyses (Evans 1994; Dijkers, 1997). Comparing these studies is further complicated by the use of a wide variety of measurement instruments, designs, analyses, and interventions (Evans, 1994; Dijkers, 1997). Also, whereas some investigators have focused on relating satisfaction with life to factors previously suggested as important to HRQL in individuals with disease or disability (as outlined by Wood-Dauphinee and Kuchler, 1992), others have stressed the importance of incorporating satisfaction with life into the model of disablement published by the World Health Organization (Figure 3; WHO, 1980).

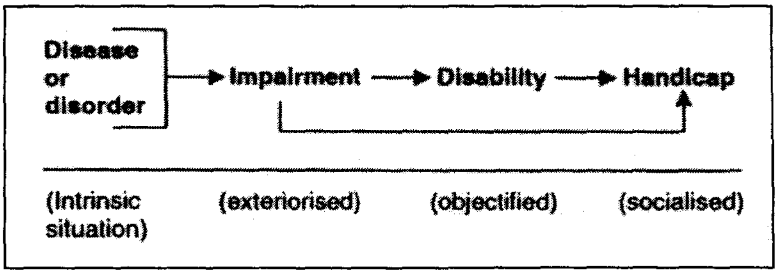


Figure 3: World Health Organization Model of Disablement (WHO, 1980)

Briefly, the model of disablement relates causally and temporally three otherwise separate terms to allow for a conceptual 'teasing apart' of the train of consequences of disease and injury (Dijkers, 1997). The terms included in the model of disablement include: 1) impairment: "any loss or abnormality of psychological, physiological or anatomical structure or function"; 2) disability: "any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being"; 3) handicap: "a disadvantage for a given individual that limits or prevents the fulfillment of a role that is normal (depending upon age, sex, social and cultural factors) for that individual". Although the umbrella term "disability" is now preferred to the use of the term "handicap" (WHO, 2001), the term "handicap" will be used throughout this paper to accurately reflect past literature. There is undoubtedly some overlap between the model of disablement and the various domains that are thought to subsume satisfaction with life; placing each of the individual domains into the model of disablement, however, is difficult. Therefore, a summary is provided of all of the factors found to be related to satisfaction with life in individuals with SCI under the terminology used in the independent studies (Table 3).

Table 3: Factors related to life satisfaction in individuals with SCI

Variables Showing a Positive Relation	References
Physical health/well-being (objective or subjective; including pain)	Decker and Schultz (1985); Dijkers (1999); Fuhrer et al. (1992); Kinney and Coyle (1992); Kreuter et al. (1998); Manns and Chad (2001); McColl and Rosenthal (1994); Putzke et al. (2002); Richards et al. (1999); Schultz and Decker (1985); Vogel et al. (1998)
Emotional well-being (e.g., depression)	Clayton and Chubon (1994); Dijkers (1999); Kreuter et al. (1998); Manns and Chad (2001); McColl and Rosenthal, (1994); Post et al. (1998b); Vogel et al. (1998)
Perceived control	Evans et al. (1994); Fuhrer et al. (1992); Decker and Schultz (1985); Schultz and Decker (1985)
Mobility/access to the environment	Dijkers, (1997); (1999); Franceschini et al. (2003); Fuhrer et al. (1992); Manns and Chad (2001); Richards et al. (1999); Vogel et al. (1998)
Social support (objective or subjective)	Decker and Schultz (1985); Dijkers (1997); Fuhrer et al. (1992); Manns and Chad (2001); McColl and Rosenthal (1994); Schultz and Decker (1985); Vogel et al. (1998)
Occupational/family roles or social integration (objective or subjective)	Clayton and Chubon (1994); Crewe (1980); Decker and Schultz (1985); Dijkers (1997); (1999); Franceschini et al. (2003); Fuhrer et al. (1992); Kreuter et al. (1998); Manns and Chad (2001); McColl and Rosenthal (1994); Post et al. (1998a); (1998b); Putzke et al. (2002); Vogel et al. (1998)
Independence/physical function/self-care ability	Manns and Chad (2001); Franceschini et al. (2003); Kreuter et al. (1998); Post et al. (1998a)
Ability for spontanaeity	Manns and Chad (2001)
Time since injury	Dijkers (1999)
Being married	Kinney and Coyle (1992); Kreuter et al. (1998); Post et al. (1998a); (1998b); (1999)
Satisfaction with sexual activity	Crewe (1980); Fuhrer et al. (1992); Post et al. (1998a)
Financial situation (objective or subjective)	Clayton and Chubon (1994); Dunnum (1990); Fuhrer et al., (1992)
Variables Showing a Negative Relation	**References**
Disability	Dijkers (1997); Evans et al. (1994)
Handicap	Fuhrer (1992); Dijkers (1997); (1999)
Social stigma	Manns and Chad (2001)

It is important to note that impairment, which is generally permanent, often was found not to be related to satisfaction with life in individuals with SCI (Cushman and Hasset, 1992; Decker and Schultz, 1985; Dijkers, 1997; 1999; Fuhrer et al., 1992; Manns and Chad, 2001; McColl and Rosenthal, 1994; Post et al., 1998a; Richards et al., 1999; Vogel et al., 1998; Westgren and Levi, 1998). In fact, Dijkers (1999) has suggested that "the impact of impairment on QOL is almost entirely through its impact on disability, and the effect of disability is largely through its effect on handicap". This suggests that, of the factors that have been found to relate to satisfaction with life in individuals with SCI (other than demographic characteristics), many have the potential to be modified by interventions. For example, although an intervention would likely have little to no effect on the extent of lower-body muscle paralysis or maximum heart rate ("impairments" due to SCI), the same intervention may contribute to improvements in the ability to walk (a "disability") and the performance of ADL (a "handicap"). Furthermore, although it is intuitive to assume that improving aspects of disabilities and handicaps will, in turn, improve overall life satisfaction, it is also possible for improved life satisfaction to translate to reductions in disabilities and handicaps (e.g., an individual with greater life satisfaction may be more likely to engage in life-enhancing activities; Dijkers, 1999).

In summary, although the literature in the area of satisfaction with life in individuals with SCI is relatively novel and often inconsistent, global satisfaction with life and HRQL tend to be reduced in individuals with SCI compared to the population at large. The studies done thus far suggest that a large number of domains (whether demographic, objective, or subjective) are related to these evaluations of reduced satisfaction with life and HRQL. Of these, depression has been studied extensively.

1.2.2.2 Effect of SCI on Depression

Depression can be defined as a "depressed mood [(a state of dysphoria that occurs routinely and is a normal process)] accompanied by persistent and pervasive loss of emotional involvement with other people, objects, or activities" (Elliott and Frank, 1996). Negative mood states, such as depression, are related to satisfaction with life (Clayton and Chubon, 1994; Kreuter et al., 1998; McColl and Rosenthal, 1994; Vogel et al., 1998) and, as a component of psychological well-being, depression is included in the emotional aspect of HRQL (Rejeski, 1996; Richards et al., 1999). According to Elliott and Frank (1996), "depression is probably the most frequently studied psychological variable among persons with SCI".

Numerous methodological issues have made the study of depression following SCI inconsistent in its findings (Elliott and Franks, 1996). Especially during acute SCI, it is possible for symptoms associated with the SCI itself (e.g., weight loss, disruptions in appetite, sleep cycles, physical sensations, energy levels, and mobility problems) to falsely seem like evidence of depressive symptomology (Elliott and Frank, 1996). Furthermore, self-report measures of depressive symptomology do not allow investigators to make a diagnosis of depression; rather, they provide an indication of the presence of thoughts, feelings, and behaviours than *often accompany* depression (Elliott and Frank, 1996). These thoughts, feelings, and behaviours themselves are susceptible to stress and transient life changes and are thus not necessarily indicative of clinical depression (Elliott and Frank, 1996). As researchers have come to realize these problems of measurement and symptom interpretation, the earlier belief that depression is an inevitable and necessary part of coping with SCI is beginning to change (DeVivo et al., 1991; Elliott and Frank, 1996; MacDonald et al., 1987); researchers are realizing that "depressive syndromes, as defined by standardized psychiatric criteria, are not universal and inevitable sequelae after SCI" (Elliott and Frank, 1996).

Notwithstanding the previously mentioned measurement concerns, in individuals with acute SCI, depressive symptomology has been identified in 19.7% (Judd et al., 1989), 22.7% (Howell et al., 1981) and 30% (22% severe, 8% minor; Kishi et al., 1994) of patients. In studies with samples of individuals with chronic SCI who are living in the community, rates of depressive symptomology have been reported at 13% (MacDonald et al., 1987) and 31% (Fuhrer et al., 1993). In contrast, depression rates among able-bodied community members have been reported in the range of 5.7% (Weismann et al., 1978) to 12% (Turner and McLean, 1989). Therefore, although depression is no longer considered to be a universal and inevitable complication following SCI, research has consistently shown that depression does occur in some individuals, and at higher levels than in the general population (Elliott and Frank, 1996; Kennedy and Rogers, 2000). This is an important realization, as depression may have both direct and indirect influences on HRQL in those who are susceptible.

Among individuals with SCI, depression has been found to be associated with: 1) poor self-assessed health status (Fuhrer et al., 1993; Schultz and Decker, 1985), 2) performance of fewer self-care activities (MacDonald et al., 1987), 3) greater handicap (social integration, mobility, and occupation; Fuhrer et al., 1993; Tate et al., 1994), 4) poor perceived control of one's life (Fuhrer et al., 1993), 5) poor availability of social support (Fuhrer et al., 1993), 6) more days spent in bed and fewer days outside the home (Tate et al., 1994), and 7) pain (Rintala et al.,1998). As many of these studies were correlational in nature, it is impossible to determine the directionality of all relationships. Nevertheless, interventions which improve the psychological well-being of individuals with SCI who express depressive symptomology likely will improve overall life satisfaction, both directly and indirectly.

1.2.3 Summary and Clinical Implications

As stated by Dijkers (1996): "A spinal cord injury is no longer the almost certain threat to life it once was… [and it] is not the catastrophe many still consider it to be". Therefore, despite the resulting decreases in physical ability (such as walking), not every individual with an SCI has reduced overall life satisfaction. Of those who do, however, there exists the possibility of a long life with reduced HRQL and overall life satisfaction. As discussed above, individuals with SCI have been shown to have decreased satisfaction with life and increased depressive symptomology compared to the able-bodied population, suggesting that both the cognitive-judgemental and the emotional aspects of HRQL can be affected by SCI (Diener et al., 1985). In short, there are likely numerous complicated reciprocal relationships between the many factors associated with overall life satisfaction and with the domains of HRQL in individuals with SCI. Rehabilitation efforts that target the improvement of HRQL are important to the long-term well-being and life satisfaction of individuals with SCI.

1.3 CONVENTIONAL REHABILITATION FOLLOWING SCI

According to Post (1998b), "rehabilitation mobilizes the resources of individuals with impairments in order to secure their social well-being and life satisfaction". Once medical stability has been achieved, current SCI rehabilitation goals include: maximization of functional recovery, prevention of medical complications, restoration of health, facilitation of independence, provision of education and support, and promotion of community reintegration (Bugaresti, 2003). In general, recovery from SCI tends to plateau within one year following injury (Van de Crommert et al., 1998). A direct assessment of QOL is done infrequently in the rehabilitation setting (Manns and Chad, 2001). In a meta-analysis, Evans and colleagues (1994) were unable to draw any conclusions about the effect of rehabilitation on QOL.

Whereas maximization of the ability to walk is an important rehabilitation outcome for all individuals with SCI at some point (Subbarao, 1991), current rehabilitation efforts are not promising in this regard (Barbeau et al., 1993). Management of postural hypotension, preservation of joint range of motion, and development of muscle under voluntary control is generally the extent of ambulation rehabilitation (Bugaresti, 2003). For those who are capable, conventional gait retraining aims to correct individual gait problems during a progression from standing to walking under full weight-bearing conditions (with the assistance of parallel bars and/or walking aids; Barbeau et al., 1993; Visintin and Barbeau, 1989). Once the individual leaves the rehabilitation setting, it becomes his/her responsibility to seek and obtain long-term rehabilitation. Residual function, energy expenditure, a patient's tolerance to orthoses, the availability of a caregiver, treatment, strength of leg muscles, and a patient's motivation are determinants of recovery of functional ambulation in individuals with SCI (Krawetz and Nance, 1996; Little et al., 1999; Subbarao 1991; Waters et al., 1994).

Lower-body functional electrical stimulation (FES) is one technique selectively available for "exercise" (Andersen et al., 1996; Greve et al., 1993; Martin et al., 1992; Mohr et al., 1997), ambulation re-training (Field-Fote, 2001; Field-Fote and Tepavac, 2002), or ambulation facilitation (Gallien et al., 1995; Klose et al., 1997) in certain individuals with SCI. Functional electrical stimulation was developed more than 40 years ago as an orthotic system to prevent foot-drop in individuals with hemiplegia (Liberson et al., 1961). Since then, through coordinated electrical stimulation, muscles which lack voluntary control have been induced to perform involuntary movements in individuals with SCI, such as stationary cycling and limited periods of standing, walking on level surfaces, and climbing stairs (Andersen et al., 1996; Yarkony et al., 1992). Although FES-cycling has shown some benefits in terms of muscle hypertrophy and favourable fibre-type shift (Andersen et al., 1996; Greve et al., 1993; Martin et al., 1992; Mohr et al., 1997), restoration of mobility through FES has been very limited; rapid development of muscle fatigue, adverse interactions with spinal reflexes, and only small increases in walking speed are reported (Barbeau et al., 1998; Dietz et al., 1997; Yarkony et al., 1992). Furthermore, the bulky, unreliable, and expensive FES stimulators are inconvenient for widespread use in rehabilitation (Stein et al., 1993). As FES remains in the experimental stage (Dietz et al., 1997), the search continues for improved functional ambulation rehabilitation techniques. Animal research has been at the forefront of the development of a new form of rehabilitation – body-weight supported treadmill training.

1.4 BODY-WEIGHT SUPPORTED TREADMILL TRAINING: A NOVEL FORM OF REHABILITATION

1.4.1 A Historical Basis for BWSTT: Animal Research

Credit is given to Charles Sherrington (1910) for the discovery that when the spinal cord is completely cut at the level of the brainstem, cats retain a limited ability to perform stepping motions (reciprocal, alternating pattern of hindlimb movements; Field-Fote, 2000; Wickelgren, 1998). Within a few years, Brown (1914) demonstrated that, even with the dorsal roots cut (to eliminate some proprioceptive input to the cord), the T12-spinalized cat could perform complex hindlimb movements. These pioneering findings led to the suspicion that, in cats, the lumbar spinal cord houses the basic neural circuitry needed for walking (Wickelgren, 1998). Not until 1967 was this suspicion confirmed, when the cat spinal cord, completely isolated from both communication with the brain and sensory-related cues from paralysed hindlimb muscles, caused alternating firing to occur in the neurons that extend the legs and those that flex them ("fictive locomotion"; cf. Wickelgren, 1998); the laboratory of Lundberg concluded that the spinal cord contains a "rhythm generator" for locomotion that is independent from the brain and sensory cues. The term "central pattern generator" (CPG) is now commonly used to refer to "an ensemble of spinal neurons whose membrane, synaptic, and network properties are capable of generating, in the absence of peripheral or descending inputs, a detailed motor pattern such as locomotion" (Rossignol and Barbeau, 1995).

Seventy years following the initial discovery by Sherrington, two independent laboratories led by Reggie Edgerton and Serge Rossignol demonstrated that adult chronic spinalized cats can "re-learn" and improve walking ability by training on a treadmill with part of their body-weight supported by the tail (Barbeau and Rossignol; 1987; Lovely et al., 1986; 1990). This finding of the ability of *adult* cats to improve stepping ability following spinalization is important because, until this time, spinalized *kittens* (with more "plastic" spinal cords) generally had been shown to be much more successful at recuperating stepping ability (Eidelberg et al., 1980; Robinson and Goldgerger, 1986; Smith et al., 1982). Findings by Edgerton and colleagues (1991) also supported the belief that training can induce functional changes in the CPG circuitry ("motor learning"), when step-trained spinalized cats became good steppers but poor standers, whereas stand-trained spinalized cats became good standers but poor steppers. The training investigations by the laboratories of Edgerton and Rossignol differed from those previous in that greatest emphasis was placed on maximizing: 1) the amount of weight-bearing during functional stepping and 2) the number of functional steps taken; partial body-weight support was provided by holding the tail only when necessary.

From this research, a general model for locomotion in the cat has been developed (Duysens and Van de Crommert, 1998). In brief, commands for initiation and termination of rhythm generation come from supraspinal levels. Afferent feedback from the moving limbs is delivered to both spinal and supraspinal levels to modulate the gait cycle to suit the environment. Either directly through the CPG, or through reflex pathways thought to be largely under the control of the CPG, the afferent feedback aids in the phase transitions during the step cycle. Based on the "implicit assumption that no fundamental differences exist between the neural networks of humans and other vertebrates", the animal-model of locomotion has been extrapolated to human locomotion (Duysens and Van de Crommert, 1998).

1.4.2 Transition to the Use of BWSTT in Humans

Impairments in strength and motor control due to neurological damage can cause gait retraining in humans with SCI to be delayed due to the inability to bear weight, perform single-limb stance, and/or advance limbs (Gardner et al., 1998). Based on the findings from animal research, Finch and Barbeau made a recommendation in 1986 for the use of body-weight supported treadmill training (BWSTT) in humans with neurological impairment. It was the lab of Hugues Barbeau and colleagues in Montreal, Quebec that was the first to use BWSTT in humans with SCI with the goal of improving the ability of patients with spastic paresis to perform a functionally appropriate gait (Visintin and Barbeau, 1989). They found that, compared to 0% body-weight support (BWS), partial unloading of body weight (up to 40%) while walking on a treadmill allowed for more normal timing of EMG activity, increased walking speed, single-limb support time, and stride length, and a straighter trunk and greater knee extension during the stance phase. Soon after this initial report of BWSTT in humans, the laboratory of Wernig and colleagues (1992) in Germany published work based on 'Laufband training': intense therapist-aided ambulation training on a BWS treadmill in individuals with SCI. Findings included a decreased need for BWS, an increase in the distance covered and in the speed of walking on the treadmill, and, in some, improved overground walking following 1 ½ to 7 months of intensive BWSTT in participants with acute and chronic incomplete injuries.

Since these initial studies, additional findings by these groups and by others have given support to the use of BWSTT as a means of improving functional ambulation in humans with SCI. In brief, BWSTT has been reported to: 1) decrease the need for BWS (Barbeau et al., 1993; Behrman and Harkema, 2000; Colombo et al., 1998; Stewart et al., submitted; Wernig et al., 1992; 1995), 2) increase the speed of walking (Barbeau et al., 1993; Behrman and Harkema, 2000; Gardner et al., 1998; Stewart et al., submitted; Protas et al., 2001; Wernig et al., 1995), 3) increase the duration/distance of walking (Barbeau et al., 1993; Behrman and Harkema, 2000; Stewart et al., submitted; Protas et al., 2001; Wernig et al., 1995), 4) improve EMG characteristics during walking (timing and/or amplitude; Barbeau et al., 1993; Colombo et al., 1998; Dietz et al., 1994; Dobkin et al., 1992; Wirz et al., 2001), 5) improve gait characteristics (e.g., joint angular displacement, stride length, footswitch; temporal pattern; Barbeau et al., 1993; Gardner et al., 1998), 6) decrease the need for assistance (therapists, devices and/or orthotics; Behrman and Harkema, 2000), 7) decrease the oxygen cost of walking (Protas et al., 2001), and 8) improve overground walking (Barbeau et al., 1993; Behrman and Harkema, 2000; Dietz et al., 1994; Stewart et al., submitted; Wernig et al., 1995; Wirz et al., 2001).

In general, it seems apparent that BWSTT is an effective intervention for improving functional ambulation in individuals with SCI, even compared to conventional rehabilitation (Wernig et al., 1995). However, the improvements described above differ for individuals with varying levels and severities of SCI and are not necessarily translated to independent overground walking ability. As the mechanism of improvement remains elusive, it is difficult to identify who can benefit from BWSTT.

1.4.3 Mechanism(s) of Walking Improvement due to BWSTT in Humans with SCI

1.4.3.1 Early Findings

In the early research done with BWSTT in humans, the dynamic and load-reducing nature of the training itself was credited for the observed improvements in functional ambulation (Barbeau et al., 1993; Visintin and Barbeau, 1989; Wernig et al., 1992); BWSTT provided the potential for intense gait re-training by anyone tolerant of an upright posture and facilitated the performance of a normalized gait cycle by reducing body-weight on the lower limbs. In 1992, however, Dobkin and colleagues observed that an individual with a complete T-6 SCI "evolved increasingly reciprocal EMG bursts in a stepping pattern" with BWSTT; therefore, it was suggested that humans, like cats, have a lumbo-sacral CPG for locomotion. Similarly, Dietz and colleagues (1994) found that in 5 individuals with acute complete paraplegia (within 4-5 weeks of injury), BWSTT resulted in greater and better-timed EMG activity. The authors further suggested that stepping could be 'induced' in these participants. Their findings were reported as support for the belief that "spinal locomotor centres can be activated in patients with paraplegia in a manner similar to that in … a chronic spinally transected cat after training on a treadmill". However, the actual meaning of 'induced' is unclear, as the authors later state that "only patients with incomplete paraplegia profited from locomotor training" (Dietz et al., 1994). Despite this initial evidence, it is often the report by Calancie and colleagues (1994) that is considered the first to have provided evidence for a CPG for locomotion in the human spinal cord. In this report, a man with a chronic, incomplete SCI (17 years post-injury) underwent an intense ambulation-training program twice daily, 5-6 days/week. Approximately 1 week following the beginning of training, the man experienced "involuntary step-like movements" while lying on his back with hips and knees fully extended. Although the authors acknowledged that that this report did not prove the presence of a human CPG for locomotion, they later suggested that they had witnessed "the first well-defined example of a central rhythm generator for stepping in the adult human" (Calancie et al, 1994). Since 1994, numerous studies have been done using BWSTT for the purpose of locomotor re-training in individuals with SCI (Barbeau et al., 1999; Behrman and Harkema, 2000; Colombo et al., 1998; Dietz et al., 1995; 1997; Dobkin et al., 1995; Field-Fote, 2001; Field-Fote and Tepavac, 2002; Gardner et al., 1998; Pepin et al., 2003a; 2003b; Protas et al., 2001; Stewart et al., submitted; Trimble et al., 2001; Wernig et al., 1995; 1998; Wirz et al., 2001); participants have included those with acute injuries or chronic injuries, paraplegia or tetraplegia, and complete or incomplete injuries. Results from these studies vary, as do the suggested mechanisms for any observed improvements. Numerous recent reviews have been written on the subject of the role (or lack thereof) of a human CPG during BWSTT (Barbeau et al., 1998; Duysens and Van de Crommert, 1998; Field-Fote, 2000; Mackay-Lyons, 2002; Van de Crommert et al., 1998). A brief summary is provided here.

1.4.3.2 Supporters of a human CPG for locomotion

A number of groups feel that they have supported the hypothesis that improvements resulting from BWSTT are due to the afferent activation of a human CGP for locomotion afforded by upright walking on a moving treadmill. This "support", however, is often given indirectly, through excluding one or more alternate possible explanations for the observed improvements. For example, Wernig et al. (1995; 1998) commented that improvements in functional ambulation in their participants with motor-incomplete SCI did not correlate with improvements in voluntary muscle activity (muscle strength and/or number of motor units recruitable and the pattern of excitation of these units). As a result, they concluded that the observed improvements in locomotor activity were partially due to "the involvement of motor automatisms" (i.e., CPGs). Similarly, the laboratory of Dietz and colleagues concluded that "the isolated human spinal cord contains the capacity not only to generate a locomotor pattern, but also 'to learn'" (Dietz et al., 1997). This conclusion followed their demonstration of the lack of or limited roles for either the stretch reflex, spontaneous recovery, or increased loading in their observations of improved leg muscle EMG activity following BWSTT in individuals with either complete or incomplete SCI (Colombo et al., 1998; Dietz et al., 1995). As a continuation of their early findings, the laboratory of Edgerton and colleagues noted that during BWSTT, the lower extremity flexor and extensor muscle EMG bursts in individuals with complete or incomplete SCI were temporally synchronized to the various phases of the step cycle and were modulated by changing the level of limb loading and treadmill speed (in terms of amplitude and duration). They concluded that: "as in the model of the cat after a thoracic spinal transection, peripheral sensory inputs that are associated with rhythmical locomotion can enhance the output of lumbosacral neural circuits that contribute to step-like EMG activity, even in the absence of supraspinal descending influences" (Dobkin et al., 1995; Harkema et al., 1997).

As a result of this evidence in support of CPGs for locomotion in humans, other groups have adopted BWSTT on the assumption that CPG activation occurs during BWSTT and allows for favourable adaptations to be made. Research out of the Spaulding Rehabilitation Hospital in Boston, Mass., accredited the improved walking ability following 6 weeks of BWSTT in their single-subject design (7 months post-injury; ASIA D) to "neural mechanisms influenced by retraining the stepping mechanism through CPG activation" (Gardner et al., 1998). An improvement in strength cannot be excluded as contributing to improvements in the outcomes of this study, however, as no lower-extremity strength measures were made. In a similar case-study format, collaborators from the Universities of Florida and California found that 4 individuals with SCI (1 ASIA A; 1 ASIA C; 2 ASIA D; 1-12 months post-injury) were able to improve walking ability on the treadmill and, in those classified as ASIA C or D, overground, following BWSTT (Behrman and Harkema, 2000). The individual with ASIA A SCI apparently achieved the ability to generate 3-10 consecutive independent steps on the treadmill with only 10% BWS, while her lower-extremity motor score remained 0/50. The observed improvements are ascribed to "the plasticity of the nervous system and its capacity to respond to locomotor-specific afferent input to generate stepping". Although the authors did not exclude a role of spontaneous recovery and (based on the ASIA lower extremity motor score), suggested that an increase in strength was not involved in the improvements by three individuals (ASIA A and both ASIA D), they did not provide any more specific explanations for the observed improvements.

Research done through the Miami Project To Cure Paralysis has incorporated the use of FES to assist leg movement during BWSTT (Field-Fote 2000; Field-Fote and Tepavac, 2001). The group found improvements in lower extremity strength and overground walking, as well as in walking speed, walking duration, and intralimb coordination on the treadmill. This training method was considered to be based on "our current understanding of the role of afferent input in the production of walking" (Field-Fote, 2000). Unfortunately, little discussion is devoted to the suggestion of mechanisms of improvement. Rather, only advantages of BWSTT are given (facilitation of step initiation due to decreased lower-extremity load and treadmill-assisted hip extension and provision of a secure environment – allowing for experimentation of movement strategies).

1.4.3.3 Alternative Explanations for Improved Ambulation Following BWSTT

Despite the evidence for a human CPG for locomotion, there has been some conflicting evidence or alternative explanations for the observed "improvements" in locomotion in individuals with SCI. It has been suggested that rhythmic passive stretching of the muscles during BWSTT is sufficient and required to induce EMG activity in individuals with complete SCI (Stewart et al., 1991). In this study, when treadmill locomotion assistance ceased in individuals with complete SCI, so did the EMG rhythmic activity. This research group has suggested that stretch-induced activity can "create the impression that the muscles are rhythmically activated" (Rossignol and Barbeau, 1995). Later studies, however, have provided evidence that stretch alone is not sufficient to elicit the EMG activity observed in individuals with complete SCI (Dietz et al., 1994; 1995; 2002; Dobkin et al., 1995; Harkema et al., 1997). In reviewing the evidence, Capaday (2002) has commented that "the generalized reflex excitability seen in SCI subjects makes it difficult to separate unequivocally patterned reflex actions from true locomotor pattern generation".

Authors have listed muscle strength among the factors that limit ability to ambulate in individuals with incomplete SCI (Field-Fote, 2000; Gardner et al., 1998) and yet many have discounted the role of muscle strength for the improvements observed in their participants (Wernig et al., 1995; 1998). It is likely that a lack of sensitivity in the measures used to determine muscle strength is the reason for the lack of observed relationship between changes in muscle strength and changes in functional ambulation among individuals with SCI (Protas et al., 2001). For example, in a study by Wirz and colleagues (2001), individuals with incomplete, acute (32-347 days post-injury) SCI had an increase in the gastrocnemius EMG activity and in walking ability following BWSTT 5 days/week; although no measures of strength were made, 6 of 8 participants initially classified as ASIA C were classified as ASIA D at the end of training, suggesting that there were improvements in strength. In a 12-month, thrice-weekly BWSTT study conducted in our laboratory, an increase in strength and/or a decrease in fatiguability were hypothesized as the mechanisms for the improvements in functional ambulation among participants; analysis of muscle biopsies revealed muscle hypertrophy following training (Stewart et al., submitted). Another possibility is that small changes in muscle strength, combined with more efficient muscle use during ambulation (Protas et al., 2001), are sufficient to cause improvements in ambulation for individuals with SCI. According to MacKay-Lyons, (2002), "accumulating physiological and behavioural evidence that adaptive processes can occur within the spinal cord has challenged the dogma that the spinal cord is a relatively non-plastic, hardwired conduit for relaying supraspinal commands". For example, the rehabilitation of stroke patients has been shown to be most effective through task-specific training, suggesting that some motor learning takes place during effective rehabilitation (Richards et al., 1993). An attempt to measure changes in motor control due to BWSTT in individuals with SCI was made by Protas and colleagues (2001) via surface EMG recordings during a series of separate volitional movements under controlled conditions. Results from this study are not strong, as there were only 3 participants, but the authors conclude that this type of measurement "appears to contribute meaningful data concerning mechanisms of responses to supported treadmill ambulation training".

An undeniable piece of evidence against the presence or role of a CPG for locomotion in humans is that, in humans with a complete SCI, BWSTT has never resulted in improvements in overground walking (Dietz 1994; 1995; Dobkin, 1995; Wernig 1992; 1995; Wirz et al., 2001) and, although there have been reports of spontaneous stepping on the treadmill (Behrman and Harkema, 2000; Dietz et al., 1994; 1995) these reports are questionable. Dobkin and colleagues (1995) explain that unassisted stepping was not possible in their participants with complete SCI despite observable EMG activity due to insufficient torque production. It has also repeatedly been suggested that gait in humans relies to a greater extent on supraspinal control and, therefore, less on a spinal CPG (MacKay-Lyons, 2002; Van de Crommert et al., 1998; Wernig et al., 1998). Evidence supporting this suggestion is provided in a recent study by Dietz and colleagues (2002) in which participants underwent loaded, passive ambulation with one leg while the other leg remained stationary. In participants without SCI, EMG activity was present in the non-moving leg, whereas in participants with complete SCI, it was absent. The authors concluded that "the spinal coordination of bilateral leg muscle activation [in humans] depends on a facilitation by supraspinal centres". The ability of spared descending pathways to influence locomotor output was demonstrated by Dobkin and colleagues (1995); only participants with an incomplete SCI (as opposed to those with a complete SCI) could alter their EMG activity when asked to voluntarily assist (rather than passively undergo) manual limb placements while walking on a treadmill. According to Van de Crommert and colleagues (1998), it remains unclear whether, in individuals with incomplete SCI, locomotion is controlled via the interaction of supraspinal contol and a spinal CPG, or whether locomotion is controlled by higher centres alone. Therefore, it may be that individuals who do not re-gain the ability for stepping have a loss or an absence of descending pathways so profound that the motoneuron pools required for stepping cannot be sufficiently excited (Van de Crommert, 1998). In general, the potential to make use of CPGs to accelerate locomotor recovery in humans may be much more difficult than it appears to be in cats (MacKay-Lyons, 2002). Furthermore, according to MacKay-Lyons (2002), "even if neuronal activity were to be restored at the spinal level, the usefulness of it may be limited by the loss of equilibrium control".

1.4.3.4 Summary: Expectations for the Ambulation Re-training Benefits of BWSTT

In conclusion, mechanism(s) for the observed improvements in walking or in step-like EMG activity in individuals with complete or incomplete SCI due to BWSTT remain(s) elusive. Although there is some research to support the presence of a CPG for locomotion in humans, it is inconsistent, indirect, rudimentary, and often based on very few subjects. Fictive locomotion (rhythmical patterns that occur in the absence of any movements), the most convincing evidence for a CPG according to Duysens and Van de Crommert (1998), has no direct equivalent in humans. The reality is that, even if a CPG were shown to exist, it is unlikely to be the answer to the re-ambulation hopes of all individuals with SCI. It seems more likely that BWSTT provides a safe training situation for anyone with neurological impairment to undergo "functional ambulation". Increases in strength and movement efficiency, as well as plastic changes in preserved pathways, may have more important roles than are currently reflected in the literature. Therefore, although this form of weight-bearing "exercise" has the potential to improve various physiological parameters (e.g., muscle morphology; Stewart et al., submitted), the extent of improvement in independent treadmill and/or overground walking (the initial reason for the development of BWSTT) appears to depend mostly on injury level and severity. As a result, even proponents of the potential benefits of BWSTT have recommended being critical and conservative when discussing the impact that BWSTT can have in the lives of individuals with SCI (Wickelgren, 1998). Conclusions made too hastily could lead to disappointment in individuals who may already be suffering from reduced quality of life.

1.4.4 Effect of Exercise on HRQL: Potential for BWSTT as an Intervention

An earlier FES-ambulation study (Guest et al., 1997) reported that, despite emphasizing the limitations of the training program prior to the beginning of the program, 3 of 15 participants were disappointed that the training did not bring about some voluntary function in their legs. However, the authors also reported that there were no increases in depressive symptomology in these disappointed participants. Although there is a possibility for disappointment following a BWSTT training program, the potential for improved HRQL due to the exercise afforded by this form of training likely outweighs the possible downfalls.

Among the numerous recognized benefits of exercise are improvements in HRQL (Lox et al., 2003; Rejeski et al., 1996). As would be thought intuitively, individuals who have the lowest initial levels of HRQL (and, therefore, have more room for improvement) benefit the most from exercise (Lox et al., 2003). Correspondingly, in a recent review, Rejeski and colleagues (1996) synthesized the evidence for the beneficial effects of exercise on HRQL in individuals with cardiovascular disease, pulmonary disease, and arthritis. As individuals with SCI have been shown to have lower levels of life satisfaction and higher levels of depressive symptomology compared to the able-bodied population (see above), this population is also likely to benefit from exercise participation (Noreau and Shephard, 1995).

The benefits of regular physical activity to the objective, physical fitness of individuals with SCI have been shown (Davis et al., 1991; DiCarlo 1988; Hooker and Wells, 1989). Research examining the role of physical activity on subjective HRQL in individuals with SCI, however, is in its infancy (Manns and Chad, 1999). In the first randomized controlled trial of exercise training in individuals with SCI to look at both physiological and psychological outcome measures, our laboratory found that "a 9-month program of twice-weekly exercise can decrease self-reported stress, pain, and depression, and can enhance physical self-concept and overall QOL in persons with SCI" (Hicks et al., 2003). Similarly, improvements in depression were found following 32 sessions of FES-assisted walking (Guest et al., 1997) in individuals with SCI. In correlational studies, higher levels of physical activity in individuals with SCI are negatively associated with depressive symptomology (Coyle and Santiago, 1995; MacDonald et al., 1987; Muraki et al., 2000).

1.4.5 Mechanism for Exercise-Induced Improvement in HRQL

In 1995, Noreau and Shephard published a review to summarize the "commonly accepted potential benefits of exercise that could improve QOL following SCI". Lox and colleagues (2003) have also provided a list of the five HRQL dimensions most likely to be affected by exercise training programs: 1) perceptions of physical functioning, 2) perceptions of health status, 3) perceptions of emotional well-being, 4) perceptions of social functioning, and 5) perceptions of cognitive functioning. Although there is some overlap between these reports of possible benefits of exercise in individuals with SCI, Noreau and Shepard (1995) focus mainly on objective aspects of QOL, whereas Lox and colleagues (2003) emphasize the role of subjective *perceptions* by the individuals of aspects of HRQL. In a focus group discussion environment, Martin and colleagues (2002) acquired the opinions of individuals with SCI as to the benefits of exercise; a number of physical, psychological, and social benefits were discussed, with "makes wheeling easier" and "makes ADL easier to perform" being mentioned most often. Therefore, there are many possible avenues for the effects of physical activity to be extended to the improvement of HRQL in individuals with SCI. Lox and colleagues (2003) emphasize, however, that an exercise intervention may cause greater improvements in some HRQL domains than others. To explain this differential effect, they provide two suggestions: 1) the various domains may have different baseline levels and/or 2) there are unique relationships between exercise and each domain. Despite the uncertainty regarding the mechanism by which exercise improves HRQL, it is agreed upon that improvements in objective indices of disease status or physical fitness are not required to see an increase in HRQL (Lox et al., 2003; Rejeski et al., 1996). After all, many individuals with chronic disease and disability partake in physical activity to regain or maintain their ability to perform ADLs that require strength and endurance, rather than to increase their physical fitness (Lox et al., 2003). Nonetheless, for exercise participation to improve subjective HRQL, the individual must: 1) perceive an improvement in his/her health and function (Lox et al., 2003) and/or 2) change the standards used to evaluate his/her health and physical, emotional, social, and cognitive functioning (Dijkers, 1999).

Hicks and colleagues (2003) suggested that the improvements in perceived QOL found following 9-months of exercise training may have been due to exercise-induced changes in pain, an improved sense of control and mastery regarding physical functioning, and/or social interactions during exercise. Although Guest and colleagues (1997) did not measure perceived QOL, their findings of decreased depression and improved physical self-concept (attributed to visible bodily changes, sense of connection with the lower body, ability to leave the chair, ability to interact with others face-to-face, and sense of achievement), would likely have translated to improved overall satisfaction with life.

In summary, through possible improvements in domains such as perceived health, perceived ability to perform ADLs, and improved depressive symptomology, participation in regular physical activity (such as BWSTT) can be beneficial to the HRQL of individuals with SCI. Therefore, if structured exercise participation is temporary (e.g., commitments to exercise only during an exercise intervention research study), the physiological and psychological benefits incurred by an exercise program should be re-evaluated following the cessation of the program to ensure that the benefits are not lost.

1.5 CESSATION OF SCI REHABILITATION: EFFECT ON FUNCTIONAL AMBULATION AND QUALITY OF LIFE

In individuals with SCI, limitations due to the injury itself or to environmental factors (such as limited access to exercise facilities and lack of transportation) create barriers to the initiation and maintenance of physical activity (Coyle and Santiago, 1995;

Martin et al., 2002). Therefore, when an individual agrees to participate in an exercise intervention study (such as BWSTT), the end of the study may also mean the end of regular access to equipment used in the intervention (e.g., BWS treadmills, accessible resistance training equipment). As a result, it is important to conduct follow-up evaluations on participants upon cessation of an exercise intervention study; the benefits which were acquired due to training may dissipate and/or the life satisfaction of the individual may worsen once the training environment is no longer available. After all, "successfully controlling lifetime secondary impairments is the mark of quality rehabilitation and is far more important than simply controlling complications during initial hospitalization" (Whiteneck, 1994).

1.5.1 Maintenance of Improved Functional Ambulation

Although a number of studies have now demonstrated improved functional ambulation following a period of BWSTT, only 3 studies were found which report on the maintenance of these improvements following the cessation of training; all 3 studies reported that in individuals who acquired the ability to ambulate (either functionally or therapeutically), the improvements were maintained, if not improved, in most cases (Field-Fote, 2001; Wernig et al., 1998; Wirz et al., 2001). Each of these studies, however, contributes in a different manner to an understanding of whether and why functional ambulation is maintained following BWSTT.

Walking capabilities assessed by Wernig and colleagues (1998) were based on a walking scale which is very insensitive to change and which may have contributed to an inability to detect clinically-relevant changes. Wirz and colleagues (2001) assessed changes in gastrocnemius medialis EMG activity during treadmill-ambulation. They found that individuals with complete SCI (who remained unable to perform voluntary stepping) "lost the 'learned' capacity of spinal neuronal networks to produce reasonable leg extensor EMG activity during assisted walking". Similarly, in the investigation by Field-Fote (2001), the one participant (out of 4) who had a decrease in overground walking speed upon follow-up testing was the only one who had a prolonged period without ambulation following the end of the training program (due to surgery).

It appears that maintenance of walking ability following the cessation of a BWSTT program is dependent upon continued ambulation-practice, whether overground or on the BWS treadmill. Correspondingly, Wernig and colleagues (1998) have suggested that continued access to a BWS treadmill might allow for continued locomotor improvement in individuals with more severe SCI. Therefore, BWSTT studies involving SCI participants with poor motor function should provide continued access to a BWS treadmill and/or should conduct a follow-up investigation of their ability to perform functional ambulation.

1.5.2 Maintenance of Improved Quality of Life

As stated by Lox and colleagues (2003), "for individuals who already enjoy a high level of HRQL, exercise may play an important role in maintaining this level".

Therefore, if an exercise intervention leads to elevated HRQL (or improved levels of domains associated with HRQL) in individuals with SCI, continued exercise adherence upon the end of the study may be required for the maintenance of the improvements. In the only identified exercise intervention follow-up study, our laboratory found a significant decrease in exercise adherence during the first 3 months after the end of a 9-month arm-ergometry and resistance training study in individuals with SCI (Ditor et al., 2003). Paralleling the decrease in adherence, there was also a significant decrease in HRQL.

Two follow-up investigations in individuals with SCI were also conducted by Craig and colleagues (1997; 1998), but following the end of cognitive behaviour therapy, not exercise. In these studies, individuals who expressed high levels of depressive mood prior to treatment benefited from cognitive behaviour therapy and maintained these benefits 12 months (Craig et al., 1997) and 24 months (Craig et al., 1998) following the end of the intervention. A possible explanation for the different findings in the follow-up studies of exercise compared to cognitive behaviour therapy is that in the initial intervention study by Craig and colleagues (1997), the participants were "newly injured". Since a self-report depression measure was used (Beck Depression Inventory) it is likely that symptoms (e.g., weight loss, disruptions in appetite and sleep cycles) and emotions associated with an acute SCI caused an overestimation of baseline depressive symptomology in these participants (Elliott and Frank, 1996). The report does not indicate whether, in a subset of individuals with high baseline depression, mean score at 2 years on the BDI differed between the treatment and control. Therefore, the long-term maintenance of reduced depressive symptomology observed by Craig and colleagues (1998) may have been due to a decrease in SCI-related symptoms over time as opposed to an actual decrease in depression as a result of the initial cognitive behaviour therapy.

In summary, very few studies have conducted a follow-up investigation after the end of an intervention designed to improve HRQL in individuals with SCI. As the number of studies using BWSTT for gait-retraining and/or exercise in individuals with SCI is increasing, it becomes important to understand the long-term psychological consequences of beginning and ending participation in BWSTT research studies.

2.0 SUMMARY AND STATEMENT OF PURPOSE (INTRODUCTION)

Traumatic spinal cord injury (SCI) causes at least some loss in sensory and motor function below the level of the lesion (Somers, 1992). As a result, there is a decreased ability for independent walking (Somers, 1992). Furthermore, satisfaction with life is decreased (Boschen, 1990; Decker and Schultz, 1985; Dijkers, 1997; 1999; Fuhrer et al., 1992; Kreuter et al., 1998; Lundqvist et al., 1991; Schulz and Decker, 1985) and depressive symptomology is increased (Fuhrer et al., 1993; MacDonald et al., 1987) in individuals with SCI compared to the general population. As life expectancy for individuals with SCI is approaching that of the able-bodied population (Canadian Paraplegic Association, 2000), there is increased importance on the development of effective long-term rehabilitation strategies.

Based on the findings that adult chronic spinalized cats can "re-learn" and improve walking ability by training on a treadmill with part of their body-weight supported by the tail (Barbeau and Rossignol; 1987; Lovely et al., 1986), body-weight supported treadmill training (BWSTT) was adopted in humans with neurological impairment in 1989 (Visintin and Barbeau, 1989). Since then, numerous laboratories have demonstrated that a BWSTT program can improve functional ambulation in individuals with SCI (Barbeau et al., 1993; Behrman and Harkema, 2000; Colombo et al., 1998; Dietz et al., 1994; Dobkin et al., 1992; Gardner et al., 1998; Protas et al., 2001; Stewart et al., in press; Wernig et al., 1992; 1995; Wirz et al., 2001). Although implemented as a gait re-training intervention, the exercise afforded by BWSTT may also lead to improvements in subjective HRQL in individuals with SCI, either directly, or indirectly through improving domains such as physical well-being (e.g., performance of activities of daily living; perceived health) or psychological well-being (e.g., depressive symptomology; Lox et al., 2003). Evidence suggests that exercise participation may contribute to enhanced HRQL (Hicks et al., 2003) or decreased depressive symptomology (Coyle et al., 1993; Guest et al., Hicks et al., 2003; 1997 MacDonald et al., 1987; Muraki et al., 2000) in individuals with SCI.

As the benefits of BWSTT and exercise participation to functional ambulation and HRQL in individuals with SCI are being recognized, it becomes important to ensure that the benefits are maintained following the cessation of an intervention. Previous literature suggests that improved functional ambulation is maintained following the cessation of a BWSTT program in individuals who developed the ability to ambulate independently (Field-Fote, 2000; Wernig et al., 1998; Wirz et al., 2001), whereas improved subjective HRQL has been shown to decrease following the cessation of an exercise program (Ditor et al., 2003).

In the longest BWSTT training study to date (12 months), 13 individuals with incomplete SCI performed thrice-weekly BWSTT in our laboratory (Hicks et al., 2002). Results included a decreased requirement for BWS ($p<.01$), and increased preferred walking speed ($p<.01$) while on the treadmill, as well as improved overground walking in 4 individuals and improved group satisfaction with life ($p<.05$). Upon completion of the 12-month BWSTT program, access to the BWS treadmill was limited to once-per-week, but participants also were invited to attend a twice-weekly fitness program (arm ergometry and resistance training). Therefore, the purpose of the present study was to determine the effects of the cessation of a 12-month BWSTT program on functional ambulation and aspects of HRQL in individuals with incomplete SCI, 8 months following the program.

3.0 METHODS

3.1 PARTICIPANTS

Eleven men and two women with incomplete (ASIA B or C), chronic (> 1 year post-injury) SCI completed a thrice-weekly 12-month body-weight supported treadmill training (BWSTT) program for which this follow-up investigation was conducted.

Inclusion and exclusion criteria for the 12-month program are described in detail elsewhere (Stewart et al., submitted). Briefly, participants had to be at least 18 years of age and diagnosed with a medically stable chronic (> 1 year since injury) traumatic SCI. Medical clearance was required to confirm that interested volunteers were free from evidence or past history of ischemic heart disease, unstable angina, dysrhythmia or autonomic dysreflexia, recent osteoporotic fracture, and tracheostomy. Participation in the follow-up investigation required that participants continue to be free from the exercise contraindication listed above and be available to return to the Centre for Health Promotion and Rehabilitation for follow-up testing.

Of the 13 participants who completed the 12-month program, only one woman was ineligible for follow-up, as her 8-month time point had already elapsed; the remaining 12 individuals agreed to participate in the follow-up investigation. The participants involved in the follow-up testing (aged 22-55) were classified with either an ASIA B or C SCI (lesion range C4 to L1) and used a wheelchair as their primary mode of locomotion. Detailed participant information is provided in table 3. This study was approved by the McMaster Research Ethics Board (MREB) and subjects provided written informed consent in accordance with MREB guidelines.

Table 3: Participant characteristics

Participant	Sex	Birth Date	ASIA Score	Level of Injury	Date of Injury	Years Post Injury*
FP	M	Oct 8 1969	C	C4	Nov 21 1999	2
CC	M	Mar 2 1977	C	C5	Mar 2 1977	24
TS	M	May 8 1967	C	C4/5/6	Jan 1 1991	11
GC	M	Oct 12 1947	C	C5	Jan 1 1998	4
DH	M	Mar 25, 1978	C	C5	Jul 27 1997	4
JL	M	Feb 19 1973	C	C4	Oct 1 1997	4
RM	M	Feb 6 1975	C	T8	Jun 13 1999	2
KD	M	May 25 1978	C	T12/L1	Oct 29 1999	2
CW	F	Oct 2 1980	C	C5	Jul 1 1996	5
BT	M	Sept 22 1971	B	C 5/6	May 1 1993	11
MS	M	Jan 1 1977	C	C 5/6	Jul 2 1992	9
PR	M	Feb 21 1969	B	T12	Jan 1 2000	2

* Relative to beginning of 12-month study

3.2 STUDY DESIGN

A longitudinal prospective study design was utilized with participants being re-evaluated approximately 8 months (37±2.1 weeks) following the cessation of a 12-month, thrice-weekly BWSTT study (144 total sessions). Comparison of follow-up results was made to baseline and 12-month results. Measures of health-related quality of life (HRQL) were the first components of follow-up testing, followed by evaluations of functional ambulation. This order of testing was chosen to prevent functional ambulation testing from affecting responses on HRQL instruments.

3.3 BWSTT AND/OR FITNESS TRAINING ADHERENCE DURING THE FOLLOW-UP PERIOD

Following completion of the 12-month BWSTT study, the participants were invited to attend once-weekly BWSTT and/or twice-weekly fitness training (arm ergometry and resistance training) offered within our Centre. Attendance was recorded by program staff or volunteers. The number of possible sessions and the actual number of sessions attended between the 12-month and follow-up testing days were determined, allowing for calculation of BWSTT adherence and exercise (BWSTT+fitness training) adherence during the follow-up period (sessions attended ÷ sessions possible × 100). BWSTT and/or fitness training frequency during the follow-up period was compared to BWSTT frequency during the training period (sessions attended ÷ total number of days in the period × 100) to ensure that the two periods differed in the % of days with BWSTT and/or fitness training. Correlations with percent changes (%change) in measures of HRQL were made with total exercise adherence (days of BWSTT and/or fitness training ÷ number of sessions available); total exercise adherence was chosen as opposed to BWSTT alone since the literature does not distinguish between different forms of exercise when evaluating the effects of exercise on HRQL in individuals with SCI. Furthermore, the number of possible fitness training days were double that of the number of possible BWSTT days, causing fitness training to account for a larger possible portion of exercise participation by the participants.

3.4 FOLLOW-UP MEASURES: LIFE SATISFACTION AND HEALTH-RELATED QUALITY OF LIFE

The study of the effect of exercise on HRQL in individuals with SCI is very novel (Manns and Chad, 2001) and, therefore, remains exploratory in nature. The measures for this follow-up investigation were chosen based on our laboratory's previous experience with exercise interventions in individuals with SCI (Hicks et al., 2003). An interview format was used, as not all participants had the ability to use paper and pencil. The internal consistency of each multi-item scale was evaluated at all 3 measurement periods (baseline, 12-months, and follow-up; table 1). Adequate internal consistency was demonstrated when Chronbach alpha values exceeded .70 (Nunnally, 1978).

3.4.1 Satisfaction with of Life

According to Fuhrer and colleagues (1994), "obtaining both global and domain-specific judgements may be especially useful in evaluating outcomes of particular rehabilitative interventions". Therefore, one global measure of satisfaction with life was used, as well as 2 measures of domains of HRQL which have been shown in the literature to be related to satisfaction with life.

3.4.1.1 Global Satisfaction With Life

The Satisfaction With Life Scale (SWLS; Diener et al., 1985) is a multi-item scale developed to allow respondents to indicate subjective satisfaction with life in general. Participants are asked to rate to what extent they agree with statements related to satisfaction with life. There are 5 items rated on a Likert scale ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). Therefore, scores can range from 5 (low satisfaction with life) to 35 (high satisfaction with life). According to Dijkers (1999), "the SWLS is one of the few existing instruments that measures life satisfaction as a global entity, rather than requiring subjects to rate their satisfaction with each of a number of domains of life". Internal reliability (range .80 to .89) and test-retest reliability (range .54 to .83) have been acceptable (Pavot and Diener, 1993). For the current study, Chronbach alpha values were indicative of adequate internal consistency (α >.70). A copy of the scale is included in Appendix C.

3.4.1.2 Perceived Ability to Perform Activities of Daily Living

There is currently no accepted measure of perceived ability to perform activities of daily living for individuals with spinal cord injury. The Instrumental Activities of Daily Living (IADL) scale (Lawton, 1982) was developed for intended use with the elderly population and asks about the help needed to perform 8 activities of daily living, including "using the telephone" and "doing housework or handyman work". The IADL scale was used in the present study. One item was modified to better reflect the lifestyle of an individual with spinal cord injury from "getting to places beyond *walking* distances" to "getting to places beyond *wheeling* distances". Participants are asked about how much help they need during ADL. When an individual says that he/she can do the ADL without any help, 2 points are given. If the individual says he/she needs some help or cannot perform the activity at all, 1 and 0 points are awarded, respectively. The maximum score is 16 (independence) and the minimum score is 0 (maximum dependence). The IADL was rated as "acceptable" by a large majority in a sample of individuals with SCI (in response to a request for their opinion about completing the scale; Andresen et al., 1999) and showed acceptable internal consistency at 12-months in the current study (alpha > .70). Internal consistency could not be calculated at baseline or follow-up due to non-variance in one or more items across the entire sample. A copy of the scale is included in Appendix C.

3.4.1.3 Perceived Health

The Medical outcomes Study (MOS) Short-Form Health Survey (SF-36; Ware and Sherbourne, 1992) is a generic measure assessing various self-perceptions of aspects of HRQL. Two items were selected to investigate the HRQL domain of perceived health. The first, "In general, you would say your health is:" has responses ranging from "Poor" (1) to "Excellent" (5). The second, "Compared to one year ago, how would you rate your health in general now?", has responses ranging from "Much Worse" (1) to "Much Better

Now" (5). These items were chosen because the longitudinal nature of this intervention has the potential to affect both current health perceptions as well as change in health perceptions. Responses to these questions were averaged. As there are only two items, Chronbach alpha values could not be calculated. A copy of the scale is included in Appendix C.

3.4.2 Depression

The Centre for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), a measure of depressive symptomatology in community-based samples, has been used in studies involving participants with SCI (Fuhrer et al., 1993; Schultz and Decker, 1985). The 20 items on the scale were rated by the respondent based on how often, during the past week, they had experienced the symptoms described. Responses range from "Rarely or none of the time" (0) to "All of the time" (3). Scores on the CES-D can range from 0-60, with a score of 16 or higher indicating an elevated risk for clinically significant depression (Fuhrer et al., 1993). Alpha coefficients of .84 to .90 have been reported from the CES-D (Radloff, 1977). For the current study, internal consistency could not be calculated due to non-variance in one or more items at all three measurement points. A copy of the scale is included in Appendix C.

3.5 FOLLOW-UP MEASURES: FUNCTIONAL AMBULATION

Functional ambulation was assessed using an overground walking test and/or a 10-minute "best effort" BWSTT session. If the individual was capable of performing overground walking, he/she was asked to return to the Centre for Health Promotion and Rehabilitation within one week of the overground walking test to perform the 10-min BWSTT session; this prevented any fatigue due to overground walking from interfering with walking ability on the treadmill. Due to a busy schedule, one individual was unable to return to the Centre on a second occasion for testing on the BWS treadmill.

3.5.1 Overground Walking

Ability to walk overground was assessed by use of a scale developed by Wernig et al. (1995) and modified for use in our facility (table 4). In brief, the Wernig walking scale is a six-item classification scheme that delineates between independent versus dependent walking, with or without ambulatory aids. Our laboratory has added to this scale so that the ability to take more or less than five steps is included in separate levels. We found that this addition significantly increased the ability of the scale to distinguish functional improvements in overground walking (Hicks et al., 2003).

Table 4: Overground walking scale developed by Wernig et al. (1995) and modified for use in our facility

Score	Description
0	No walking capability, even with the help of 2 therapists
1	Capable of walking < 5 steps with the help of 2 therapists OR along parallel bars
2	Capable of walking ≥ 5 steps with the help of 2 therapists OR along parallel bars
3	Capable of walking > 1 length of the parallel bars, requiring assistance to turn
4	Capable of walking > 1 length of the parallel bars, turning independently
5	Capable of walking along railing (< 5 steps) with the help of one therapist
6	Capable of walking along railing (≥ 5 steps) with the help of one therapist
7	Capable of walking with a rolling walker frame ≥ 5 steps
8	Capable of walking with canes or crutches ≥ 5 steps
9	Capable of walking without devices ≥ 5 steps

3.5.2 Percentage of Body-Weight Support and Treadmill Speed

BWSTT is a relatively unique rehabilitation technique, whereby individuals with SCI are supported upright on a motor-driven treadmill (Woodway USA Inc., Foster, CT) by a harness mechanism; an overhead pulley system uses dynamic counterbalancing to support a percentage of the participant's body-weight. One therapist is positioned at each of the legs of the participant to assist in the performance of a functional gait. As much as possible, full knee extension is performed during the stance phase of the gait cycle. The therapists provide as little assistance as is required for the performance of a functional gait, allowing the participant freedom to perform as much of an independent gait as is possible with one or both legs.

Each participant performed a 10-minute "best effort" BWSTT session (lowest possible BWS and highest comfortable speed). Speed and BWS parameters were determined by first attempting to use a level of BWS equivalent to that which was used at the end of the 12-month BWSTT training program. If a "crouched" walk resulted, or if the participant found the level of BWS to be too low, the BWS was increased until a comfortable level was attained. The participant then chose the fastest possible comfortable walking speed and, with the help of one therapist positioned at each leg, performed a 10-minute BWSTT session. A minimum of 10 minutes was set for the BWSTT session, since this duration was attained by all participants by the end of the 12-month BWSTT program. Following completion of the 10-min BWSTT session, each participant's body weight was taken and the %BWS supported by the treadmill was calculated.

3.6 STATISTICAL ANALYSES

To test for intervention effects, a series of one-way, repeated measures (baseline, 12-month, and follow-up), analyses of variance (ANOVA) were performed. When a significant main effect for time was found, a Tukey post-hoc test was used to compare means at the 3 measurement points. All correlations were determined by calculating a Pearson product moment correlation coefficient. Statistical significance was set at p<.05. Data are reported as means±standard deviation throughout the text.

4.0 RESULTS

4.1 12-MONTH BWSTT STUDY: A REVIEW

For the 12 participants who underwent follow-up testing, compliance during the 12-month BWSTT program was 77.5±6.7% (range 66.7% to 85.7% of possible sessions completed). The thrice-weekly training resulted in a decrease in the required %BWS (from 73±10% at baseline to 19±12% at study end; p<.01), an increase in treadmill walking speed (0.5±0.3 at baseline to 1.4±0.8 km/h at study end; p<.01), and improved overground walking in 4 individuals. Table 7 presents descriptive statistics for each psychological HRQL and satisfaction with life outcome measure at all time points (baseline, 12-month, and follow-up). A repeated-measures ANOVA revealed a significant improvement in satisfaction with life following 12-months of BWSTT (p<.05). As shown in table 8, at 12-months, higher reported satisfaction with life was associated with a higher perceived ability to perform ADL (r = .81; p<.01) and with lower depressive symptomology (r = -.69; p<.05). There was also a non-significant relationship between high perceived ability to perform ADL and low depressive symptomology (r = -.56; p=.10).

4.2 EXERCISE ADHERENCE DURING THE FOLLOW-UP PERIOD

Adherence to the available once-weekly BWSTT sessions during the follow-up period was only 31.7±26.8% (range 0.0 to 82.9%). The adherence to combined once-weekly BWSTT and twice-weekly fitness training was even lower, at 22.5±26.5% (range 0.0 to 71.4%). Of the total number of days during the 12-month study and during the follow-up period, the percentage of days of exercise at our Centre (BWSTT and/or fitness training) was significantly lower during the follow-up period (11.5±11.3%) than during the 12-month training period (33.2±2.9%; p<.01).

4.3 CHANGES IN FUNCTIONAL AMBULATION ON THE BWS TREADMILL: PERCENT BODY-WEIGHT SUPPORT AND SPEED

One participant (FP) did not return to our Centre for testing on the BWS treadmill. The required %BWS for treadmill training increased at follow-up compared to 12-months (from 19.5±12.2 to 34.9±14.4; p<.01), but remained below pre-training values (73.1±10.3; p<.01; figure 2). The individual changes in %BWS were not correlated to BWSTT adherence during the follow-up period. There were no changes in preferred walking speed on the treadmill from 12-months to follow-up (1.4±0.8 km/h at both).

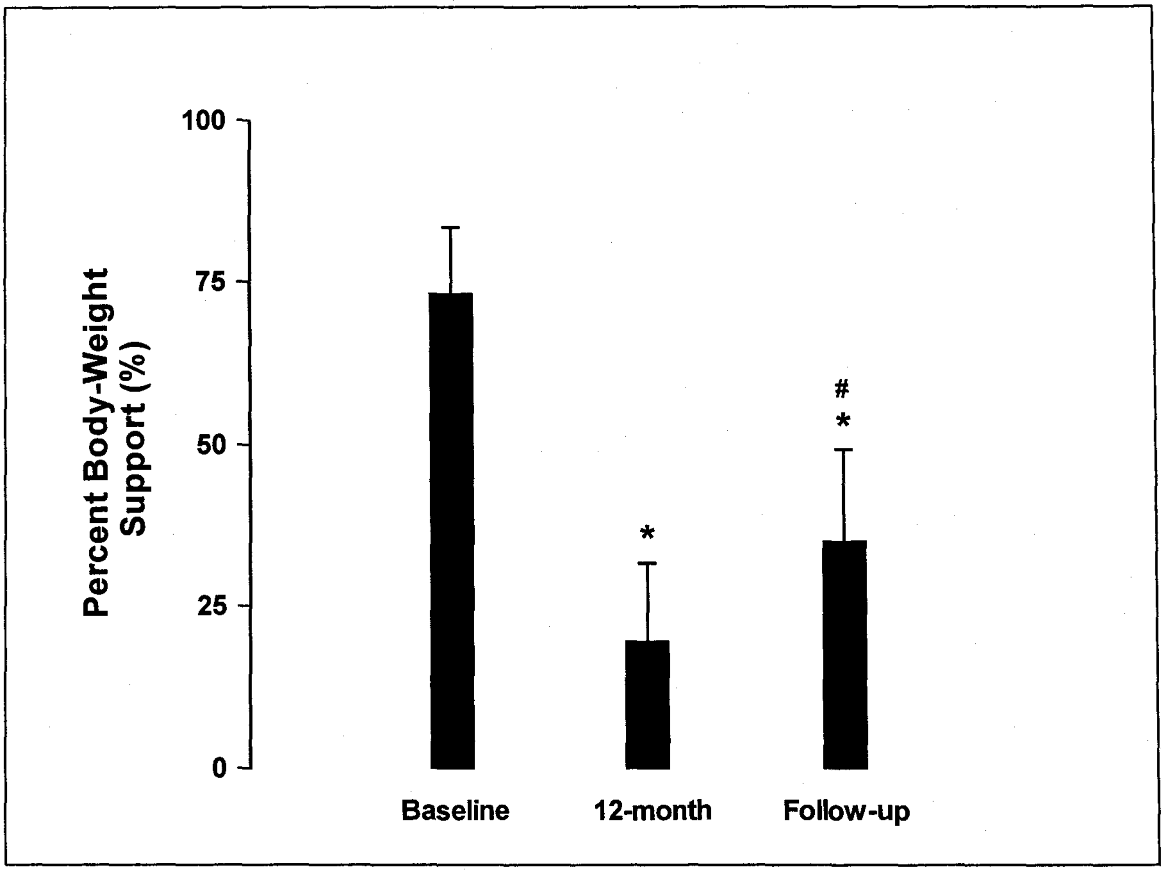


Figure 4: Baseline, 12-month, and follow-up comparisons of required %BWS during ambulation on the BWS treadmill. * = significantly different from Baseline (p<.01). # = significantly different from 12-months (p<.01).

4.4 CHANGES IN OVERGROUND WALKING

There were no changes in mean overground walking score from 12-months to follow-up. Of the four individuals who improved their overground walking during the 12-month program (FP, CC, RM, KD), results were mixed regarding change upon follow-up testing (table 6). FP had a one-point drop in his overground walking score, as he chose to use his cane for his walk; the result, however, was an increase in the distance walked in an equivalent duration compared to 12-months. RM had an increase in distance and duration while walking in parallel bars; high clonus in this individual created the need for many standing breaks during the walking test. KD had an increase in distance covered in an approximately equivalent amount of time. The walking test of CC was performed despite no longer having access to the leg braces and walker used during the 12-month test. The result was a dramatic decrease in both distance and duration.

Table 6: Overground walking score, time, and distance in the 4 individuals who were able to perform the overground walking test at 12-months

Participant	12-months			Follow-up		
	Score	Time (min)	Distance (m)	Score	Time (min)	Distance (m)
FP	9	6:43	29.7	8	6:50	118.8
CC	7	51:29	594.0	7	4:00	33.8
RM	4	2:32	10.0	4	4:25	17.1
KD	7	7:25	118.8	7	7:09	178.2

4.5 CHANGES IN LIFE SATISFACTION AND HEALTH-RELATED QUALITY OF LIFE

One participant (PR) who completed the follow-up walking testing did not complete the follow-up life satisfaction and HRQL measures. The 12-month data for the IADL scale was missing from one participant (FP) and, therefore, omitted from the analyses.

4.5.1 Changes in HRQL after cessation of training

In this sub-group of participants from the 12-month BWSTT study, a series of repeated-measures ANOVAs revealed no differences between 12-month and follow-up scores on life satisfaction or any HRQL-related measures (table 7; p>.69 in all cases). Mean scores on perceptions of health and depressive symptomology at follow-up remained non-significantly different from baseline. There were non-significant trends for increases in satisfaction with life and perceived ability to perform ADLs at follow-up compared to baseline (table 7; p=.12 and p=.11, respectively).

Table 7: Baseline, 12-month and follow-up group descriptive statistics for HRQL-related measures

Measure	**Baseline**		**12-months**		**Follow-up**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Satisfaction with Life	18.7	7.9	23.4*	7.6	22.3^{t}	8.6
Perceived ability to perform ADL	12.6	1.7	13.4	2.6	13.6^{t}	1.9
Perceptions of Health	4.0	0.6	4.2	0.7	4.0	0.7
Depression	7.8	4.3	7.3	5.0	8.1	7.0

* = p<.05 compared to baseline
t = non-significant trend compared to baseline
Note: Baseline, 12-month and follow-up group means for perceived ability to perform ADL are reported for only 10 of 11 participants.

4.5.2 Correlations Among Life Satisfaction and HRQL Measures at Follow-up

At follow-up, there were non-significant trends for correlations of lower depressive symptomology with: 1) higher reported satisfaction with life (r = -.59; p=.06) and 2) better perceived health (r = -.52; p=.10). There was also a non-significant trend for high perceived health to be correlated with high perceived ability to perform ADLs (r = .55; p=.10).

Table 8: Correlations between scores on all psychological measures at 12-months and at follow-up

Measures	1	2	3	4
		12-months (n = 11)		
1. SWLS	--	.81**	.28	-.69*
2. IADL[a]		--	.31	-.56[t]
3. SF-36			--	-.24
4. CES-D				--
		Follow-up (n = 11)		
1. SWLS	--	.31	.34	-.59[t]
2. IADL[a]		--	.55[t]	-.02
3. SF-36			--	-.52[t]
4. CES-D				--

a = correlations were performed with only 10 participants
t = non-significant trend
* = p<.05
** = p<.01

4.5.3 Correlations Among Changes on HRQL-Related Measure Scores and with Exercise Adherence During the Follow-up Period

Analyses were undertaken to see if %changes in life satisfaction and HRQL were related to each other and to exercise adherence. Percent change scores on the SWLS and on the CES-D were negatively correlated (r = -.61; p<.05); individuals who had improved satisfaction with life during the follow up period also tended to have reduced depressive symptomology. Exercise adherence (BWSTT + Fitness Training) during the follow up period had a strong positive correlation with %change in perceived ability to perform ADL (r = .70; p<.05). Non-significant trends were present between high exercise adherence during the follow-up period and: i) positive %change in perceptions of health and ii) negative %change in depressive symptomology (r = .49; p=.13 and r = -.51; p=.11, respectively). Exercise adherence during the follow-up period only had a non-significant, positive weak correlation with %change in satisfaction with life (r = .23; p=.51).

Table 9: Correlations between percent change scores on all psychological measures (12-months to follow-up) and exercise adherence during the follow-up period (BWSTT+Wheelers)

Measures	**1**	**2**	**3**	**4**	**5**
1. %Δ SWLS	--	r = .24	r = -.43	r = -.61*	r = .23
2. %Δ IADL[a]		--	r = -.09	r = -.12	r = .70*
3. %Δ SF-36			--	r = -.10	r = .49[t]
4. %Δ CES-D				--	r = -.51[t]
5. Exercise Adherence					--

a = correlations were performed with only 10 participants
t = trend
* = <.05

5.0 DISCUSSION

BWSTT is becoming commonly investigated as a rehabilitation strategy to improve functional ambulation in individuals with SCI (Field-Fote, 2000; Stewart et al., submitted; Wernig et al., 1998). Novel evidence for the ability of exercise training to improve perceived quality of life in individuals with SCI (Hicks et al., 2003) has led researchers to become aware of the further possible benefits of BWSTT. In the longest BWSTT study to date, our laboratory showed that following 12-months of thrice-weekly BWSTT, individuals with incomplete SCI (ASIA B or C) improved their functional ambulation on the treadmill and overground (in four individuals), and reported improved satisfaction with life (Martin et al., unpublished; Stewart et al., submitted).

Arguably even more important than the discovery that BWSTT is beneficial to gait-retraining and QOL, is the knowledge of whether any improvements due to BWSTT are maintained following the cessation of the program. As the availability of BWSTT and exercise programs remain limited for individuals with SCI (Martin et al., 2002), it is important to ascertain that the benefits incurred by a BWSTT program are not lost upon cessation of participation. Therefore, 8 months following the completion of our 12-month BWSTT study, we conducted follow-up testing on functional ambulation and quality of life in 12 of the 13 participants who completed the 12-month program. Results suggest that some of the improvements in functional ambulation are maintained despite limited availability to the BWS treadmill. Furthermore, in general, continued exercise participation was associated with maintenance/improvement of satisfaction with life and aspects of HRQL.

5.1 EXERCISE ADHERENCE DURING FOLLOW-UP COMPARED TO EXERCISE COMPLIANCE DURING THE 12-MONTH PROGRAM

As per the study design, individuals who agreed to participate in the 12-month BWSTT program were required to complete 144 BWSTT sessions (3 sessions/week, 4 weeks/month, 12 months/year). Immediately following the study, all participants were invited to participate in once-weekly BWSTT as well as twice-weekly fitness training (arm ergometry and resistance training). Although the total possible number of exercise days per week remained the same during the follow-up period as during the training period, the percentage of total days with some form exercise at our Centre dropped significantly (from 33.2±2.9% to 11.5±11.3%; $p<.01$). The large range in exercise adherence during the follow-up period (0.0 to 71.4%) demonstrates that some individuals felt that continued exercise at the Centre for Health Promotion and Rehabilitation was both beneficial and convenient, whereas others did not. A number of individuals lived long distance from the Centre, acquired full-time employment since the training study, or had access to exercise equipment either in or near their home. This may have caused them to choose to cease attending the Centre on a regular basis. Previous follow-up studies have not reported on the specific exercise attendance or walking-practice of their participants following the cessation of BWSTT training (Field-Fote, 2001; Wernig et al., 1998; Wirz et al., 2001).

Of our participants who continued to attend, many took an initial "break" upon completion of their commitment to the study before beginning regular attendance once again. As this break took place early during the follow-up period, overall attendance during the follow-up period may be under-estimated compared to attendance at the end of the follow-up period. Nevertheless, overall group attendance during the follow-up period was significantly lower than during the training period ($p<.01$).

5.2 CHANGES IN FUNCTIONAL AMBULATION: TREADMILL SPEED AND %BWS, AND OVERGROUND WALKING

5.2.1 Group Results

Similar to results from other studies that included follow-up testing upon completion of a BWSTT training program (Field-Fote, 2001; Wernig et al., 1998; Wirz et al., 2001), our participants did not have a decrease in overground walking score or preferred walking speed upon follow-up. However, it must be noted that our 12-month BWSTT program did not result in an increase in mean overground walking score. Although the overground walking scale initially developed by Wernig and colleagues (1995) has been modified for use in our Centre, it remained insensitive to change in our participants throughout the training and follow-up periods. This may be explained by the fact that any score greater than zero on the scale requires the participants to be able to walk overground; only 4 participants in our study had the ability to walk overground before and/or after training. As the ASIA class "C" is the broadest of all ASIA classes based on motor function, there can be a great degree of variability in locomotor function outcomes in participants classified as ASIA C (Field-Fote et al., 2001). A scale more sensitive to changes in walking ability *on the BWS treadmill* would be useful in identifying changes in groups of individuals with only limited motor abilities.

The evaluation of preferred walking speed in this population also has limitations. Since most of our participants were unable to make independent steps consistently with both legs during BWSTT, the treadmill speed often depended just as much, if not more, on the abilities of the trainers to move the legs of the participant as it did on the preferences of the participants. Duration (or endurance) on the treadmill could not be evaluated during this follow-up investigation because the follow-up BWSTT session was limited to 10 minutes to ensure that all participants could attain an equal duration on the treadmill.

The results from the present study also differ from those of others (Field-Fote, 2001; Wernig et al., 1998; Wirz et al., 2001) in the demonstration that functional ambulation ability decreased for our group of participants following cessation of training: required %BWS during ambulation on the BWS treadmill increased compared to 12-months ($p<.01$). This difference can be explained in that, unlike the participants in other follow-up studies, most of ours were unable to practise walking following cessation of the BWSTT program. The inability to walk overground in most, combined with the overall poor attendance at available BWSTT sessions during the follow-up period apparently was not sufficient to fully maintain the improved ability to bear weight during assisted ambulation in our participants. Encouraging, however, was the finding that the required %BWS remained below pre-training levels ($p<.01$), suggesting that the level of activity performed by our participants was sufficient to maintain at least some of the improvements that were incurred by BWSTT.

Although we did not measure lower extremity strength or motor ability, we hypothesize that the losses in ability to bear weight were due to decreases in strength and/or decreased efficiency in use of available strength and motor function. We anticipate that manual muscle testing would not have detected any strength gains, as has been shown before despite improved gait function (Protas et al., 2001; Wernig et al., 1992). The finding of muscle hypertrophy following 6 months of BWSTT in a subset of our participants with ASIA C SCI, however, suggests that increases in strength had occurred in parallel with improved ability to bear weight (Stewart et al., submitted).

As practise of walking appears to be important to the maintenance of functional ambulation (Field-Fote, 2001; Wirz et al., 2001), it was expected that unchanged (or improved) %BWS would be correlated with high BWSTT attendance during the follow-up period. This was not the case. It is possible that the maximum number of sessions attended did not provide an amount of practise that differed from no attendance at all. It is also possible that the ranges of attendance and of change in %BWS were not sufficient to reveal a correlation with such a small sample size. Also likely, is that functional ability differed among all participants enough so that, even though they are all classified as "motor-incomplete", the potential for improved ambulation was limited to a different extent for all individuals. Therefore, the effects of BWSTT and of cessation of BWSTT would have a different influence on the walking abilities of our various participants. If it were possible to control for "functional ability" (perhaps via a sensitive measure of motor function), a correlation might be found between change in %BWS and walking-practice during follow-up (BWSTT and in the home/community).

5.2.2 Case-Evaluations of Participants Capable of Overground Walking

The inconsistent results observed in the 4 individuals who improved their overground walking can be explained by the simple fact that walking ability in individuals with SCI is affected by a myriad of life situations. In short, participant motivation, availability of consistent assistive walking devices, and varying degrees of clonus during walking can all affect results of an overground walking test. Specifically, in the individual with high clonus (RM), varying degrees of clonus during the 12-month and follow-up testing may have varied the amount of overall static standing required during the overground walking test; a greater amount of rest would likely have allowed for a greater distance and/or duration of walking. Also, changes in assitive-device use or availability likely affected walking ability in two of our participants (FP and CC). Walking ability appears to have decreased in one participant who chose to use a cane for walking during the follow-up testing, but not during the 12-month testing. However, if walking ability is based on speed and/or duration, this same individual's ability appears to have increased, as the distance travelled doubled in the same duration of walking at follow-up. Lastly, one participant acquired leg braces and a walker specifically for the 12-month training period. Upon cessation of the study, the devices were donated to a charity. As a result, walking ability during the follow-up period was dramatically reduced in this individual, as he only had use of a walker available within our Centre. In short, the inconsistent changes in overground walking during testing in this ASIA C population are considered valuable as a further example of the need for a sensitive, valid, and reliable method of evaluating walking ability on the BWS treadmill (Field-Fote, 2001).

5.3 LIFE SATISFACTION AND HEALTH-RELATED QUALITY OF LIFE

5.3.1 Changes in Satisfaction With Life

5.3.1.1 Maintenance of Improved Satisfaction With Life

Global satisfaction with life improved significantly following participation in a 12-month BWSTT study in our laboratory. Eight months following the cessation of the BWSTT study, satisfaction with life did not differ significantly from 12-months, but only had a trend for a maintained significant increase relative to baseline. Therefore, improvements in satisfaction with life due to 12-months of thrice-weekly BWSTT mostly are maintained 8 months following the cessation of training, even with relatively poor exercise adherence during the follow-up period. This finding differs from an earlier finding by our laboratory of a significant decrease in HRQL only 3 months following the cessation of a 9-month exercise training study (Ditor et al., 2003). There are many possible reasons for this discrepancy. Firstly, we might have observed a decreased satisfaction with life among the participants of the current study 3 months following the cessation of training; perhaps in our earlier study, the observed decrease in perceived quality of life at 3-months would have been followed by a gradual increase back up to post-training values as the participants adapted to the decreased exercise participation. Alternatively, as mentioned earlier, many participants in the current study took a break immediately following the completion of commitment to the BWSTT study prior to resuming regular attendance. Perhaps it was an initial decrease in satisfaction with life by these participants which prompted their return to our Centre. However, as suggested by (Fuhrer, 1994), many aspects of life affect satisfaction with life. Therefore, it is possible that events other than exercise participation occurred in the lives of these individuals during the 8-months of the follow-up period to affect satisfaction with life. With such a small sample size, the effects of exercise are difficult to isolate.

Secondly, the two initial intervention studies performed in our laboratory (Hicks et al., 2003; Stewart et al., submitted) differed in the mode of exercise training during the study period (arm ergometry and resistance training vs. BWSTT). Therefore, upon completion of the earlier study, the participants had available to them exactly the same exercise program as during the study (fitness training 2x/week), but perhaps with a reduced feeling of "obligation" to participate. As for the participants in the current study, although access to the BWS treadmill was reduced from 3x/week to 1x/week upon completion of the BWSTT study, the option of participating in twice-weekly fitness training was *added*. Therefore, it is possible that the participants in the current study benefited from two possible modes of exercise training during the follow-up period, including one mode which was relatively novel. It must be also noted that only exercise participation at the Centre for Health Promotion and Rehabilitation was included in monitoring exercise adherence in the current study. Therefore, the possibility exists that exercise participation outside of the Centre contributed to the maintenance of BWSTT-induced improvements in satisfaction with life in our participants.

Thirdly, although both the SWLS (Diener et al., 1985) used in the current study and the Perceived Quality of Life Scale (PQLS; Patrick et al., 1988) used in the earlier study are designed to measure global satisfaction with life, the items included in each instrument may differ in how they are affected by an exercise intervention; the PQLS measures the satisfaction of the individual with various component of HRQL whereas the SWLS measures life satisfaction as a global entity (Dijkers, 1999). Nevertheless, the positive finding of maintained improved satisfaction with life 8 months following the cessation of a 12-month BWSTT study should aid to reassure investigators that the cessation of an exercise intervention study will not necessarily result in a return of improved psychological well-being outcomes to pre-training levels.

5.3.1.2 Non-significant Changes Due to Training or upon Follow-up in Perceived Ability to Perform ADLs, Perceptions of Health, or Depression

The non-significant trend for increased perceived ability to perform ADLs at follow-up compared to baseline suggests that initiation of a structured BWSTT program may allow for gradual improvements in strength and/or endurance, which translate to improved independence. It is possible that the 12-month BWSTT program allowed for only small increases in perceived ability to perform ADLs, which, over time during the follow-up period, continued to increase through regular practice. This perceived increase may or may not have been due to actual improvements, and/or to lowering of standards used to judge what is satisfactory (Dijkers, 1999). Since poor physical function/independence/self-care ability has been shown to be related to reduced satisfaction with life in individuals with SCI (Manns and Chad, 2001; Franceschini et al., 2003; Kreuter et al., 1998; Post et al., 1998a), this is an important preliminary finding.

Physical strain during performance of ADL has been shown to be inversely related to parameters of physical capacity (e.g., isometric strength, and maximal arm ergometry power output; Janssen et al., 1994) and exercise training was shown to increase submaximal arm ergometry power output and upper body muscle strength (Durán et al., 2001; Hicks et al., 2003) in individuals with SCI. It follow, therefore, that exercise training has the potential to increase the ease with which ADLs are performed in individuals with SCI. As mentioned above, however, subjective evaluations of ADL performance are not necessarily reflected by objective evaluations (Rejeski et al., 1996). Therefore, perceptions of participants in terms of the benefits of an intervention are just as important (if not more) than results indicated by an objective and/or physiological measure (Boswell et al., 1998; Dijkers, 1996; Fuhrer, 1994; Lox et al., 2003). Although there are many objective standardized ADL rating scales (Watson et al., 1994), there is no accepted subjective measure of ADL performance in individuals with SCI. In summary, although exercise training has been shown to be beneficial to the performance of ADL in individuals with SCI, we are currently unable to validly and reliably measure improvements in ADL as perceived by the individual.

The self-reported answers on the IADL scale (Lawton, 1982) used in the current study may have been insensitive to change in this ASIA B and C population. Where some items on the scale were consistently rated highly on the IADL scale (e.g., "using the telephone"), others were consistently low (e.g., "doing housework/handyman work" and "doing laundry"). As only one our of participants had the ability to walk overground in his home, doing handyman work beyond reaching distance while sitting would obviously be difficult, if not impossible for this population. Similarly, as some laundry facilities remain inaccessible to wheelchairs, it could be societal constraints, as opposed to physical impairments, which prevent the performance of some ADL. Therefore, an exercise intervention would obviously have had very little role, if any at all, in improving actual or perceived ability to perform these two activities, both of which are included in the IADL scale. Effort should be made to develop a subjective ADL scale which is sensitive to change in individuals with SCI with limited/no walking ability. In light of the above discussion, the trend for improved perceived ability to perform ADL in our participants at follow-up compared to baseline is very encouraging.

In contrast to the positive findings in terms of perceived ability to perform ADL, there were no significant change scores on the CES-D (7.8±4.3 to 7.3±5.0) or the SF-36 perceptions of health items (4.0±0.6 to 4.2±0.7) following training or upon follow-up. As a score greater than 16 on the CES-D is indicative of high risk for depression, it is evident that, as a group, our participants had low depressive symptomology even before training, making it difficult to induce change. The mean CES-D score for a community-based sample of 489 Canadians (ages 22-64) was reported at 7.4 (SD not given; Turner and McLean, 1989), suggesting that our sample did not differ from the general population in terms of depressive symptomology. This finding of low baseline group depressive symptomology in individuals with SCI is similar to that of Craig and colleagues (1997). In contrast, Fuhrer and colleagues (1993) had a mean CES-D score of 12.1±9.6 in their community-based sample of 100 men and 40 women with SCI. Self-selection could explain the lower baseline mean CES-D score in our sample compared to that of Fuhrer and colleagues (1993); those individuals who are most willing to join a long-term exercise program, such as BWSTT, are likely those with the lowest levels of baseline depressive symptomology. As a result, measuring depressive symptomology may not be necessary when evaluating the effects of exercise training in individuals with SCI. In a particularly large sample, however, it may be possible to create sub-groups based on baseline depressive symptomology; a sub-group with high baseline depressive symptomology would be most likely to show decreases in depressive symptomology following an exercise intervention.

Similar to the floor effect that likely explains our failure to reduce depressive symptomology, a ceiling effect may explain the lack of change in perceived health throughout the training and follow-up studies; a maximum score of 5 can be reached on the perceptions of health items, making a baseline score of 4.0±0.6 difficult to improve upon. Once again, those individuals in the community who generally consider themselves to be healthy are probably most likely to join and remain committed to an exercise intervention study. Level of depression has been shown to predict exercise adherence in individuals with coronary heart disease, with reports of greater depression at baseline predicting poorer exercise adherence (Glazer et al., 2002; Ziegelstein et al., 2000). Although no changes were observed in these two measures, this follow-up study did demonstrate that neither participation in BWSTT nor the cessation of training led to increases in depression or decreases in perceptions of health. After all, it was possible for the initiation of BWSTT to have caused increased depressive symptomology or decreased perceived health, as the participants could have, for example, i) become disappointed if the effects of BWSTT were less than expected (e.g., Guest et al., 1997), ii) realized the amount of help needed for ambulation on the treadmill, and/or iii) developed pressure sores due to the harness. Similarly, cessation of training could have increased depression or decreased perceptions of health if the individual: i) became upset that regular BWS treadmill access was reduced, ii) became sedentary, and/or iii) missed the social interaction afforded by BWSTT sessions.

5.3.2 Correlations Among Scores on Satisfaction with Life and HRQL Measures

The only consistent correlation between scores on the HRQL-measures at 12-months and at follow-up was a negative relationship between satisfaction with life and depressive symptomology. This correlation is in agreement with previous studies which found low depression to be associated with high satisfaction with life (Kreuter et al., 1998; Manns and Chad, 2001).

Previous studies have also found higher subjective or objective evaluations of physical function/independence/self-care ability to be associated with higher satisfaction with life (Manns and Chad, 2001; Franceschini et al., 2003; Kreuter et al., 1998; Post et al., 1998a). Where a high satisfaction with life score was strongly correlated with high perceived ability to perform ADL at 12-months in our study ($r = .81$), it was only weakly correlated at follow-up ($r = .31$). Similarly, while there was a non-significant trend for a correlation between a high perceived ability to perform ADL and low depressive symptomology at 12-months, this correlation disappeared at follow-up. From 12-months to follow-up, 2 individuals had a decreased IADL score, 5 participants stayed the same, and 3 had further increased at follow-up; it is possible that, during the 8-month follow-up period, individuals changed the importance they placed on their perceived ability to performs ADL. As a result, perceived ability to perform ADL would no longer have remained strongly correlated with the SWLS or CES-D scores. Perhaps a measure that evaluates *satisfaction* with ability to perform ADL would be better suited to identifying the relative importance of ADL performance to satisfaction with life.

We found satisfaction with life to be only weakly positively correlated with perceived health at 12-months and follow-up. Numerous previous studies have found higher perceived health to be associated with higher satisfaction with life (Decker and Schultz, 1985; Dijkers, 1999; Fuhrer et al., 1992; Kinney and Coyle, 1992; Kreuter et al., 1998; Manns and Chad, 2001; McColl and Rosenthal, 1994; Putzke et al., 2002; Richards et al., 1999; Schultz and Decker, 1985; Vogel et al., 1998). The small variability in life satisfaction and perceived health scores among participants in our small sample may have prevented a stronger correlation from being identified. Furthermore, as being healthy was a requirement for participation in our long-term BWSTT study, it is likely that our participants had relatively stable health. Therefore, perceptions of health simply may not have been a strong determinant of satisfaction with life in this group of individuals.

There was a non-significant trend for a correlation between low depressive symptomology and high perceptions of health at follow-up only. Previous studies have also identified this relationship (Fuhrer et al., 1993; Schultz and Decker, 1985). Once again, the relatively small variability in perceptions of health, combined with the small sample size, may have prevented stronger correlations to be identified in our study.

5.3.3 Correlations Among Changes in HRQL-Related Measure Scores and Exercise Adherence During the Follow-up Period

The only significant correlation among follow-up period %change scores on the HRQL-related measures was a negative association between depressive symptomology and satisfaction with life. This finding agrees with our finding of a significant correlation and of a non-significant trend for a correlation between low depressive symptomology and high satisfaction with life in our participants at 12-months and follow-up, respectively. As a large number of changes could have occurred in the lives of our individuals during the 8-month follow-up period to affect satisfaction with life, it is not surprising that changes in the few domains we measured did not have strong correlations with changes in satisfaction of life during this period.

High exercise adherence during the follow-up period had a significant correlation with a positive %change on the IADL, as well as trends for correlations with positive %change on the SF-36 items and negative %change on the CES-D. It is very encouraging to note the strong correlation between high exercise adherence and increased perceived ability to perform ADL (r = .70); future research should strive to maximize the increased independence (resulting from an increased ability to perform ADL) in individuals with SCI through provision of appropriately-designed exercise programs. The finding of an association between decreasing depressive symptomology and high exercise adherence during the follow-up period agrees with previous correlational studies that have identified that higher levels of physical activity in individuals with SCI are negatively associated with depressive symptomology (Coyle et al., 1993; MacDonald et al., 1987; Muraki et al., 2000). The association of improving perceptions of health with high exercise adherence makes intuitive sense, as the benefits of regular physical activity to the objective, physical fitness of individuals with SCI have been shown (Davis et al., 1991; DiCarlo 1988; Hooker and Wells, 1989). Taken together, these findings support the emerging belief that exercise participation can improve psychological well-being in individuals with SCI (Noreau and Shepherd, 1995).

Although all 3 domains previously shown to be related to satisfaction with life were correlated with exercise adherence, satisfaction with life itself was only weakly correlated with exercise adherence (r = .23). As suggested by Fuhrer (1994), "people's happiness is determined by a host of factors, only a few of which can be influenced by rehabilitation providers and the network of services upon which the maintenance of rehabilitation gains depend". Therefore, initiation and maintenance of a structured exercise program is likely only one among a number of factors which are strong influences on overall satisfaction with life. As the SWLS is a 5-item global measure of satisfaction with life (Diener et al., 1985), it may not reflect those domains of SWL which are directly or indirectly influenced by exercise participation. Therefore, a correlation of even .23 is an encouraging finding which promotes the need for future research into the effects of exercise on psychological well-being in individuals with SCI.

5.4 CLINICAL IMPLICATIONS

As availability of BWS treadmills remains limited and often only during participation in a research study, it is important to consider the effects of initiation and subsequent cessation of a regular BWSTT program on outcomes measures such as functional ambulation, satisfaction with life, and HRQL. In general, results from this study suggest that in a group of individuals with ASIA B or C SCI, improvements in functional ambulation following a long-term BWSTT program are not completely lost 8 months following the cessation of regular training. However, as not all individuals develop the ability to walk overground, availability of a BWS treadmill provides the only opportunity for upright walking practice in these individuals. As the physiological benefits of BWSTT are becoming apparent (e.g., Stewart et al., submitted), programs which include BWSTT would be beneficial to the long-term exercise training of individuals with limited walking ability.

The findings presented above also suggest that the neither initiation nor cessation of a BWSTT program have a negative influence on HRQL in individuals with incomplete SCI. Furthermore, any improvements in HRQL due to a BWSTT program appear to be maintained following cessation of training, although continued longitudinal research should be conducted. Offering continued exercise participation upon cessation of a BWSTT study contributes to maintenance/further improvements of domains previously shown to be associated with satisfaction with life, even if the program includes only limited access to a BWS treadmill. As the results presented in this study are mostly correlational in nature, it is impossible to determine directionality of the relationships found. Therefore, although it would be attractive to assume that, in our study, exercise adherence during the follow-up period had an influence on improving perceived ability to perform ADL and perceptions of health, and decreasing despressive symptomatology, it is possible for the direction to have been opposite. In other words, clinicians should remain open to the possibility that higher perceived ability to perform ADL, better perceptions of health, and lower despressive symptomatology are the characteristics of those individuals who tend to adhere to an exercise program. Therefore, non exercise-based interventions which improve these characteristics may contribute to improved exercise adherence in individuals with SCI. As exercise has numerous definite physiological benefits in individuals with SCI (Davis et al., 1991; DiCarlo 1988; Hooker and Wells, 1989), this would be a valuable endeavour.

5.5 STUDY LIMITATIONS

Due to ethical considerations, we chose not to prevent any interested individuals from participating in the 12-month BWSTT study and, therefore, did not have a control group for this study. As a result, we are unable to ascertain that observed changes in functional ambulation and aspects of HRQL during the 12-month BWSTT study were due to training. By extension, changes in these same outcome measures during the follow-up period cannot be accredited solely to cessation of regular thrice-weekly BWSTT. Also due to ethical considerations, we did not restrict physical activity and exercise participation by our participants during the follow-up period. As a result, it is possible that exercise participation occurred outside of that monitored in the Centre for Health Promotion and Rehabilitation. In the future, follow-up investigations should attempt to have a record of any physical activity during the follow-up period so that all exercise can be accounted for when identifying differences between individuals.

With the relatively small sample size in our 12-month BWSTT study and, therefore, this follow-up study, caution must be used when generalizing results to the larger SCI population. Firstly, although all participants for this follow-up study had an incomplete SCI, the actual preserved motor function varied widely between participants (from no motor function to independent walking ability). Therefore, changes in functional ambulation presented in this study cannot even be generalized to those with an *incomplete* SCI. Furthermore, it is likely that self-selection by the participants in this longitudinal exercise study led to a sample with better overall baseline life satisfaction and HRQL compared to the general SCI population.

Lastly, the outcome measures used in this study may not have been appropriately valid and reliable for this population. For example, especially in individuals with no motor function, the level of required BWS and the speed of the treadmill during a BWSTT session may depend mostly, if not completely, on the abilities of the therapists to move the legs of the participants. Also, the satisfaction with life and HRQL-related measures used may not have addressed the concerns specific to individuals with SCI and, therefore, may not have been appropriately sensitive to change. For example, a measure of *satisfaction with* perceived ability to perform ADL that includes items such as "getting into and out of bed" and "getting dressed" may be more appropriate than the IADL scale (Lawton et al., 1982) used in this study.

5.6 SUMMARY AND CONCLUSIONS

In summary, results from this study suggest that, even with very limited access to the BWS treadmill, much of the improvement in treadmill walking ability and satisfaction with life following long-term BWSTT in individuals with incomplete SCI can be retained for at least 8 months. Continued exercise participation, however, may contribute to maintain or further improve aspects of satisfaction with life and HRQL in this population. Furthermore, as evidence is surfacing about the benefits of BWSTT to various physiological parameters in individuals with SCI (e.g., Stewart et al., submitted), provision of regular BWSTT would benefit even those who do not acquire the ability to walk independently overground.

REFERENCES

Andersen, J. L., Mohr, T., Biering-Sorensen, F., Galbo, H., & Kjaer, M. (1996). Myosin heavy chain isoform transformation in single fibres from m. vastus lateralis in spinal cord injured individuals: effects of long- term functional electrical stimulation (FES). *Pflugers Arch.* **431**, 513-518.

Andresen, E. M., Fouts, B. S., Romeis, J. C., & Brownson, C. A. (1999). Performance of health-related quality-of-life instruments in a spinal cord injured population. *Arch.Phys.Med.Rehabil.* **80**, 877-884.

Barbeau, H. & Rossignol, S. (1987). Recovery of locomotion after chronic spinalization in the adult cat. *Brain Res.* **412**, 84-95.

Barbeau, H., Danakas, M., & Arsenault, B. (1993). The effects of locomotor training in spinal cord injured subjects: a preliminary study. *Restor.Neurol.Neurosci.* **5** , 81-84.

Barbeau, H., Norman, K., Fung, J., Visintin, M., & Ladouceur, M. (1998). Does neurorehabilitation play a role in the recovery of walking in neurological populations? *Ann.N.Y.Acad.Sci.* **860**, 377-392.

Barbeau, H., Ladouceur, M., Norman, K. E., Pepin, A., & Leroux, A. (1999). Walking after spinal cord injury: evaluation, treatment, and functional recovery. *Arch.Phys.Med.Rehabil.* **80**, 225-235.

Behrman, A. L. & Harkema, S. J. (2000). Locomotor training after human spinal cord injury: a series of case studies. *Phys.Ther.* **80**, 688-700.

Boschen, K. A. Life Satisfaction, Housing Satisfaction, and Locus of Control: A Comparison Between Spinal Cord Injured and Non-Disabled Individuals. *Can.J.Rehabil.* **4**[2], 75-85. 1990.

Boswell, B. B., Dawson, M., & Heininger, E. Quality of Life as Defined by Adults with Spinal Cord Injuries. *J.Rehab.* 64, 27-33. 1998.

Brown, T. G. (1914). On the nature of the fundamental activity of the nervous centres. *J.Physiol. (Lond)* **48**, 18.

Bugaresti, J. Spinal cord injury acute and early rehabilitation management. 2003. Personal Communication

Calancie, B., Needham-Shropshire, B., Jacobs, P., Willer, K., Zych, G., & Green, B. A. (1994). Involuntary stepping after chronic spinal cord injury. Evidence for a central rhythm generator for locomotion in man. *Brain* **117 (Pt 5)**, 1143-1159.

Charlifue, S. W., Weitzenkamp, D. A., & Whiteneck, G. G. (1999). Longitudinal outcomes in spinal cord injury: aging, secondary conditions, and well-being. *Arch.Phys.Med.Rehabil.* **80**, 1429-1434.

Clayton, K. S. & Chubon, R. A. (1994). Factors associated with the quality of life of long-term spinal cord injured persons. *Arch.Phys.Med.Rehabil.* **75**, 633-638.

Colombo, G., Wirz, M., & Dietz, V. (1998). Effect of locomotor training related to clinical and electrophysiological examinations in spinal cord injured humans. *Ann N Y Acad Sci* **860**, 536-538.

Coyle, C. P. & Santiago, M. C. (1995). Aerobic exercise training and depressive symptomatology in adults with physical disabilitie. *Arch.Phys.Med.Rehabil.* **76**, 647-652.

Craig, A. R., Hancock, K., Dickson, H., & Chang, E. (1997). Long-term psychological outcomes in spinal cord injured persons: results of a controlled trial using cognitive behavior therapy. *Arch.Phys.Med.Rehabil.* **78**, 33-38.

Craig, A. R., Hancock, K., Chang, E., & Dickson, H. (1998). Immunizing against depression and anxiety after spinal cord injury. *Arch.Phys.Med.Rehabil.* **79**, 375-377.

Crewe, N. (1980). Quality of life. The ultimate goal in rehabilitation. *Minn.Med.* **63**, 586-589.

Crozier, K. S., Graziani, V., Ditunno, J. F., Jr., & Herbison, G. J. (1991). Spinal cord injury: prognosis for ambulation based on sensory examination in patients who are initially motor complete. *Arch.Phys.Med.Rehabil.* **72**, 119-121.

Cushman, L. A. & Hassett, J. (1992). Spinal cord injury: 10 and 15 years after. *Paraplegia* **30**, 690-696.

Davis, G., Plyley, M. J., & Shephard, R. J. (1991). Gains of cardiorespiratory fitness with arm-crank training in spinally disabled men. *Can.J.Sport.Sci.* **16**, 64-72.

De Vivo, M. J., Richards, J. S., Stover, S. L., & Go, B. K. (1991). Spinal cord injury. Rehabilitation adds life to years. *West J.Med.* **154**, 602-606.

Decker, S. D. & Schulz, R. (1985). Correlates of life satisfaction and depression in middle-aged and elderly spinal cord-injured persons. *Am.J Occup.Ther.* **39**, 740-745.

DiCarlo, S. E. (1988). Effect of arm ergometry training on wheelchair propulsion endurance of individuals with quadriplegia. *Phys.Ther.* **68**, 40-44.

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. The Satisfaction With Life Scale. *J.Pers.Assess.* **49**, 71-75. 1985.

Dietz, V., Colombo, G., & Jensen, L. (1994). Locomotor activity in spinal man. *Lancet* **344**, 1260-1263.

Dietz, V., Colombo, G., Jensen, L., & Baumgartner, L. (1995). Locomotor capacity of spinal cord in paraplegic patients. *Ann.Neurol.* **37**, 574-582.

Dietz, V., Wirz, M., & Jensen, L. (1997). Locomotion in patients with spinal cord injuries. *Phys.Ther.* **77**, 508-516.

Dijkers, M. Quality of life after spinal cord injury. *Am.Rehabil.* **3**, 18-24. 1996.

Dijkers, M. (1997). Quality of life after spinal cord injury: a meta analysis of the effects of disablement components. *Spinal Cord.* **35**, 829-840.

Dijkers, M. P. (1999). Correlates of life satisfaction among persons with spinal cord injury. *Arch.Phys.Med.Rehabil.* **80**, 867-876.

Ditor, D. S., Latimer, A. E., Ginis, K. A., Arbour, K. P., McCartney, N., & Hicks, A. L. (2003). Maintenance of exercise participation in individuals with spinal cord injury: effects on quality of life, stress and pain. *Spinal Cord* **41**, 446-450.

Dobkin, B. H., Edgerton, V. R., Fowler, E., & Hodgson, J. A. (1992). Training induces rhythmic locomotor EMG patterns in subjects with complete SCI. *Neurology* **42**, 207-208.

Dobkin, B. H., Harkema, S., Requejo, P., & Edgerton, V. R. (1995). Modulation of locomotor-like EMG activity in subjects with complete and incomplete spinal cord injury. *J.Neurol.Rehabil.* **9**, 183-190.

Dunnum, L. (1990). Life satisfaction and spinal cord injury: the patient perspective. *J.Neurosci.Nurs.* **22**, 43-47.

Duran, F. S., Lugo, L., Ramirez, L., & Eusse, E. (2001). Effects of an exercise program on the rehabilitation of patients with spinal cord injury. *Arch.Phys.Med.Rehabil.* **82**, 1349-1354.

Duysens, J. & Van de Crommert, H. W. (1998). Neural control of locomotion; The central pattern generator from cats to humans. *Gait Posture* **7**, 131-141.

Edgerton, V. R., Roy, R. R., Hodgson, J. A., Prober, R. J., de Guzman, C. P., & de Leon, R. (1991). A physiological basis for the development of rehabilitative strategies for spinally injured patients. *J.Am.Paraplegia Soc.* **14**, 150-157.

Eidelberg, E., Story, J. L., Meyer, B. L., & Nystel, J. (1980). Stepping by chronic spinal cats. *Exp.Brain Res.* **40**, 241-246.

Elliott, T. R. & Frank, R. G. (1996). Depression following spinal cord injury. *Arch.Phys.Med.Rehabil.* **77**, 816-823.

Evans, R. L., Hendricks, R. D., Connis, R. T., Haselkorn, J. K., Ries, K. R., & Mennet, T. E. (1994). Quality of life after spinal cord injury: a literature critique and meta-analysis (1983-1992). *J.Am.Paraplegia Soc.* **17**, 60-66.

Field-Fote, E. C. (2000). Spinal cord control of movement: implications for locomotor rehabilitation following spinal cord injury. *Phys.Ther.* **80**, 477-484.

Field-Fote, E. C. (2001). Combined use of body weight support, functional electric stimulation, and treadmill training to improve walking ability in individuals with chronic incomplete spinal cord injury. *Arch.Phys.Med.Rehabil.* **82**, 818-824.

Field-Fote, E. C. & Tepavac, D. (2002). Improved intralimb coordination in people with incomplete spinal cord injury following training with body weight support and electrical stimulation. *Phys.Ther.* **82**, 707-715.

Flanagan, J. C. (1982). Measurement of quality of life: current state of the art. *Arch.Phys.Med.Rehabil.* **63**, 56-59.

Franceschini, M., Di Clemente, B., Rampello, A., Nora, M., & Spizzichino, L. (2003). Longitudinal outcome 6 years after spinal cord injury. *Spinal Cord.* **41**, 280-285.

Fuhrer, M. J., Rintala, D. H., Hart, K. A., Clearman, R., & Young, M. E. (1992). Relationship of life satisfaction to impairment, disability, and handicap among persons with spinal cord injury living in the community. *Arch.Phys.Med.Rehabil.* **73**, 552-557.

Fuhrer, M. J., Rintala, D. H., Hart, K. A., Clearman, R., & Young, M. E. (1993). Depressive symptomatology in persons with spinal cord injury who reside in the community. *Arch.Phys.Med.Rehabil.* **74**, 255-260.

Fuhrer, M. J. (1994). Subjective well-being: implications for medical rehabilitation outcomes and models of disablement. *Am.J.Phys.Med.Rehabil.* **73**, 358-364.

Gallien, P., Brissot, R., Eyssette, M., Tell, L., Barat, M., Wiart, L., & Petit, H. (1995). Restoration of gait by functional electrical stimulation for spinal cord injured patients. *Paraplegia* **33**, 660-664.

Gardner, M. B., Holden, M. K., Leikauskas, J. M., & Richard, R. L. (1998). Partial body weight support with treadmill locomotion to improve gait after incomplete spinal cord injury: a single-subject experimental design. *Phys.Ther.* **78**, 361-374.

Glazer, K. M., Emery, C. F., Frid, D. J., & Banyasz, R. E. (2002). Psychological predictors of adherence and outcomes among patients in cardiac rehabilitation. *J Cardiopulm.Rehabil* **22**, 40-46.

Greve, J. M., Muszkat, R., Schmidt, B., Chiovatto, J., Barros Filho, T. E., & Batisttella, L. R. (1993). Functional electrical stimulation (FES): muscle histochemical analysis. *Paraplegia* **31**, 764-770.

Guest, R. S., Klose, K. J., Needham-Shropshire, B. M., & Jacobs, P. L. (1997). Evaluation of a training program for persons with SCI paraplegia using the Parastep 1 ambulation system: part 4. Effect on physical self-concept and depression. *Arch.Phys.Med.Rehabil.* **78**, 804-807.

Harkema, S. J., Hurley, S. L., Patel, U. K., Requejo, P. S., Dobkin, B. H., & Edgerton, V. R. (1997). Human lumbosacral spinal cord interprets loading during stepping. *J Neurophysiol.* **77**, 797-811.

Hicks, A. L., McCartney, N., Phillips, S., Smith, M., Radforth, L. (2002). The effects of body-weight supported treadmill training on walking ability in persons with incomplete spinal cord injury. *CJAP* **27**, S21.

Hooker, S. P. & Wells, C. L. (1989). Effects of low- and moderate-intensity training in spinal cord-injured persons. *Med.Sci. Sports Exerc.* **21**, 18-22.

Howell, T., Fullerton, D. T., Harvey, R. F., & Klein, M. (1981). Depression in spinal cord injured patients. *Paraplegia* **19**, 284-288.

Janssen, T. W., van Oers, C. A., Veeger, H. E., Hollander, A. P., van der Woude, L. H., & Rozendal, R. H. (1994). Relationship between physical strain during standardised ADL tasks and physical capacity in men with spinal cord injuries. *Paraplegia* **32**, 844-859.

Judd, F. K., Stone, J., Webber, J. E., Brown, D. J., & Burrows, G. D. (1989). Depression following spinal cord injury. A prospective in-patient study. *Br.J.Psychiatry* **154**, 668-671.

Kennedy, P. & Rogers, B. (2000). Reported quality of life of people with spinal cord injuries: a longitudinal analysis of the first 6 months post-discharge. *Spinal Cord* **38**, 498-503.

Kinney, W. B. & Coyle, C. P. (1992). Predicting life satisfaction among adults with physical disabilities. *Arch Phys.Med.Rehabil.* **73**, 863-869.

Kishi, Y., Robinson, R. G., & Forrester, A. W. (1994). Prospective longitudinal study of depression following spinal cord injury. *J.Neuropsychiatry Clin.Neurosci.* **6**, 237-244.

Klose, K. J., Jacobs, P. L., Broton, J. G., Guest, R. S., Needham-Shropshire, B. M., Lebwohl, N., Nash, M. S., & Green, B. A. (1997). Evaluation of a training program for persons with SCI paraplegia using the Parastep 1 ambulation system: part 1. Ambulation performance and anthropometric measures. *Arch.Phys.Med.Rehabil.* **78**, 789-793.

Krause, J. S. (1998). Dimensions of subjective well-being after spinal cord injury: an empirical analysis by gender and race/ethnicity. *Arch.Phys.Med.Rehabil.* **79**, 900-909.

Krawetz, P. & Nance, P. (1996). Gait analysis of spinal cord injured subjects: effects of injury level and spasticity. *Arch.Phys.Med.Rehabil.* **77**, 635-638.

Kreuter, M., Sullivan, M., Dahllof, A. G., & Siosteen, A. (1998). Partner relationships, functioning, mood and global quality of life in persons with spinal cord injury and traumatic brain injury. *Spinal Cord.* **36**, 252-261.

Lawton, M. P., Moss, M., Fulcomer, M., & Kleban, M. H. (1982). A research and service oriented multilevel assessment instrument. *J.Gerontol.* **37**, 91-99.

Liberson, W. T., Holmquest, H. J., Scott, D., & Dow, A. (1961). Functional electrotherapy: Stimulation of the peroneal nerve synchronized with the swing phase of the gait in hemiplegic patients. *Arch.Phys.Med.Rehabil.* **42**, 101-105.

Little, J. W., Ditunno, J. F., Jr., Stiens, S. A., & Harris, R. M. (1999). Incomplete spinal cord injury: neuronal mechanisms of motor recovery and hyperreflexia. *Arch.Phys.Med.Rehabil.* **80**, 587-599.

Lovely, R. G., Gregor, R. J., Roy, R. R., & Edgerton, V. R. (1986). Effects of training on the recovery of full-weight-bearing stepping in the adult spinal cat. *Exp.Neurol.* **92**, 421-435.

Lovely, R. G., Gregor, R. J., Roy, R. R., & Edgerton, V. R. (1990). Weight-bearing hindlimb stepping in treadmill-exercised adult spinal cats. *Brain Res.* **514**, 206-218.

Lox, C. L., Martin, K. A., & Petruzello, S. J. (2003). *The Psychology of Exercise: Integrating Theory and Practice* Holcomb Hathaway, Publishers, Inc., Scottsdale.

Lundqvist, C., Siosteen, A., Blomstrand, C., Lind, B., & Sullivan, M. (1991). Spinal cord injuries. Clinical, functional, and emotional status. *Spine* **16**, 78-83.

MacDonald, M. R., Nielson, W. R., & Cameron, M. G. (1987). Depression and activity patterns of spinal cord injured persons living in the community. *Arch.Phys.Med.Rehabil.* **68**, 339-343.

MacKay-Lyons, M. (2002). Central pattern generation of locomotion: a review of the evidence. *Phys.Ther.* **82**, 69-83.

Manns, P. J. & Chad, K. E. (2001). Components of quality of life for persons with a quadriplegic and paraplegic spinal cord injury. *Qual.Health Res.* **11**, 795-811.

Marieb, E. N. (2002). The Central Nervous System. In *Anatomy and Physiology* pp. 370-420. Benjamin Cummings, Toronto.

Martin, K. A., Latimer, A. E., Francoeur, C., Hanley, H., Watson, K., Hicks, A. L., & McCartney, N. M. (2002). Sustaining exercise motivation and participation among people with spinal cord injury: Lessons learned from a 9-month intervention. *Palaestra* **18**, 38-40.

Martin, T. P., Stein, R. B., Hoeppner, P. H., & Reid, D. C. (1992). Influence of electrical stimulation on the morphological and metabolic properties of paralyzed muscle. *J Appl.Physiol* **72**, 1401-1406.

Maynard, F. M., Jr., Bracken, M. B., Creasey, G., Ditunno, J. F., Jr., Donovan, W. H., Ducker, T. B., Garber, S. L., Marino, R. J., Stover, S. L., Tator, C. H., Waters, R. L., Wilberger, J. E., & Young, W. (1997). International Standards for Neurological and Functional Classification of Spinal Cord Injury. American Spinal Injury Association. *Spinal Cord.* **35**, 266-274.

McColl, M. A. & Rosenthal, C. (1994). A model of resource needs of aging spinal cord injured men. *Paraplegia* **32**, 261-270.

McDonald, J. W. & Sadowsky, C. (2002). Spinal-cord injury. *Lancet* **359**, 417-425.

Mohr, T., Andersen, J. L., Biering-Sorensen, F., Galbo, H., Bangsbo, J., Wagner, A., & Kjaer, M. (1997). Long-term adaptation to electrically induced cycle training in severe spinal cord injured individuals. *Spinal Cord.* **35**, 1-16.

Muraki, S., Tsunawake, N., Hiramatsu, S., & Yamasaki, M. (2000). The effect of frequency and mode of sports activity on the psychological status in tetraplegics and paraplegics. *Spinal Cord.* **38**, 309-314.

Noreau, L. & Shephard, R. J. (1995). Spinal cord injury, exercise and quality of life. *Sports Med.* **20**, 226-250.

Nunnally, J. C. (2003). *Psychometric theory*, 2 ed. McGraw-Hill, New York, NY.

Pavot, W. & Diener, E. (1993). Review of the Satisfacation With Life Scale. *Psychol. Assess.* **5**, 164-172.

Pearson, K. G. (2001). Could enhanced reflex function contribute to improving locomotion after spinal cord repair? *J.Physiol.* **533**, 75-81.

Pepin, A., Norman, K. E., & Barbeau, H. (2003). Treadmill walking in incomplete spinal-cord-injured subjects: 1. Adaptation to changes in speed. *Spinal Cord* **41**, 257-270.

Pepin, A., Ladouceur, M., & Barbeau, H. (2003). Treadmill walking in incomplete spinal-cord-injured subjects: 2. Factors limiting the maximal speed. *Spinal Cord* **41**, 271-279.

Post, M. W., de Witte, L. P., van Asbeck, F. W., van Dijk, A. J., & Schrijvers, A. J. (1998). Predictors of health status and life satisfaction in spinal cord injury. *Arch.Phys.Med.Rehabil.* **79**, 395-401.

Post, M. W., van Dijk, A. J., van Asbeck, F. W., & Schrijvers, A. J. (1998). Life satisfaction of persons with spinal cord injury compared to a population group. *Scand J Rehabil.Med.* **30**, 23-30.

Protas, E. J., Holmes, S. A., Qureshy, H., Johnson, A., Lee, D., & Sherwood, A. M. (2001). Supported treadmill ambulation training after spinal cord injury: a pilot study. *Arch.Phys.Med.Rehabil.* **82**, 825-831.

Putzke, J. D., Richards, J. S., Hicken, B. L., & DeVivo, M. J. (2002). Predictors of life satisfaction: a spinal cord injury cohort study. *Arch.Phys.Med.Rehabil.* **83**, 555-561.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *App.Phsychol.Meas.* **1**, 385-401.

Rejeski, W. J., Brawley, L. R., & Shumaker, S. A. (1996). Physical activity and health-related quality of life. *Exerc.Sport Sci.Rev.* **24**, 71-108.

Richards, C. L., Malouin, F., Wood-Dauphinee, S., Williams, J. I., Bouchard, J. P., & Brunet, D. (1993). Task-specific physical therapy for optimization of gait recovery in acute stroke patients. *Arch.Phys.Med.Rehabil.* **74**, 612-620.

Richards, J. S., Bombardier, C. H., Tate, D., Dijkers, M., Gordon, W., Shewchuk, R., & DeVivo, M. J. (1999). Access to the environment and life satisfaction after spinal cord injury. *Arch.Phys.Med.Rehabil.* **80**, 1501-1506.

Rintala, D. H., Loubser, P. G., Castro, J., Hart, K. A., & Fuhrer, M. J. (1998). Chronic pain in a community-based sample of men with spinal cord injury: prevalence, severity, and relationship with impairment, disability, handicap, and subjective well-being. *Arch.Phys.Med.Rehabil.* **79**, 604-614.

Robinson, G. A. & Goldberger, M. E. (1986). The development and recovery of motor function in spinal cats. I. The infant lesion effect. *Exp.Brain Res.* **62**, 373-386.

Rossignol, I. S. & Barbeau, H. (1995). New approaches to locomotor rehabilitation in spinal cord injury. *Ann.Neurol.* **37**, 555-556.

Schulz, R. & Decker, S. (1985). Long-term adjustment to physical disability: the role of social support, perceived control, and self-blame. *J.Pers.Soc.Psychol.* **48**, 1162-1172.

Sherrington, C. C. (1910). Flexion-reflex of the limb, crossed extension-reflex, and reflex stepping and standing. *J.Physiol. (Lond)* **40**, 28-121.

Smith, J. L., Smith, L. A., Zernicke, R. F., & Hoy, M. (1982). Locomotion in exercised and nonexercised cats cordotomized at two or twelve weeks of age. *Exp.Neurol.* **76**, 393-413.

Somers, M. (1992). *Spinal cord injury: functional rehabilitation* Prentice Hall Canada, Inc., Toronto.

Stein, R. B., Belanger, M., Wheeler, G., Wieler, M., Popovic, D. B., Prochazka, A., & Davis, L. A. (1993). Electrical systems for improving locomotion after incomplete spinal cord injury: an assessment. *Arch.Phys.Med.Rehabil.* **74**, 954-959.

Stewart, B. G., Hicks, A. L., McCartney, N., Mahoney, D. J., Staron, R. S., Tarnopolsky, M. A., & Phillips, S. M. (submitted). Body weight supported treadmill training-induced changes in muscle phenotype, blood lipids, and ambulatory capacity in individuals with incomplete spinal cord injury. *JAP*.

Stewart, J. E., Barbeau, H., & Gauthier, S. (1991). Modulation of locomotor patterns and spasticity with clonidine in spinal cord injured patients. *Can.J.Neurol.Sci.* **18**, 321-332.

Subbarao, J. V. (1991). Walking after spinal cord injury. Goal or wish? *West J.Med.* **154**, 612-614.

Tate, D., Forchheimer, M., Maynard, F., & Dijkers, M. (1994). Predicting depression and psychological distress in persons with spinal cord injury based on indicators of handicap. *Am.J.Phys.Med.Rehabil.* **73**, 175-183.

Trimble, M. H., Behrman, A. L., Flynn, S. M., Thigpen, M. T., & Thompson, F. J. (2001). Acute effects of locomotor training on overground walking speed and H-reflex modulation in individuals with incomplete spinal cord injury. *J.Spinal Cord.Med.* **24**, 74-80.

Turner, R. J. & McLean, P. D. (1989). Physical disability and psychological distress. *Rehabil.Psychol.* **34**, 225-241.

Van de Crommert, H. W., Mulder, T., & Duysens, J. (1998). Neural control of locomotion: sensory control of the central pattern generator and its relation to treadmill training. *Gait Posture* **7**, 251-263.

Visintin, M. & Barbeau, H. (1989). The effects of body weight support on the locomotor pattern of spastic paretic patients. *Can.J.Neurol.Sci.* **16**, 315-325.

Vogel, L. C., Klaas, S. J., Lubicky, J. P., & Anderson, C. J. (1998). Long-term outcomes and life satisfaction of adults who had pediatric spinal cord injuries. *Arch.Phys.Med.Rehabil.* **79**, 1496-1503.

Ware, J. E., Jr. & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med.Care* **30**, 473-483.

Waters, R. L., Adkins, R. H., Yakura, J. S., & Sie, I. (1994). Motor and sensory recovery following incomplete paraplegia. *Arch.Phys.Med.Rehabil.* **75**, 67-72.

Watson, A. H., Kanny, E. M., White, D. M., & Anson, D. K. (1995). Use of standardized activities of daily living rating scales in spinal cord injury and disease services. *Am.J.Occup.Ther.* **49**, 229-234.

Weismann, M. M., Myers, J. K., & Harding, P. S. (1978). Psychiatric disorders in a U.S. urban community: 1975-76. *Am.J.Psychiatry* **135**, 459-462.

Wernig, A. & Muller, S. (1992). Laufband locomotion with body weight support improved walking in persons with severe spinal cord injuries. *Paraplegia* **30**, 229-238.

Wernig, A., Muller, S., Nanassy, A., & Cagol, E. (1995). Laufband therapy based on 'rules of spinal locomotion' is effective in spinal cord injured persons. *Eur.J. Neurosci.* **7**, 823-829.

Wernig, A., Nanassy, A., & Muller, S. (1998). Maintenance of locomotor abilities following Laufband (treadmill) therapy in para- and tetraplegic persons: follow-up studies. *Spinal Cord* **36**, 744-749.

Westgren, N. & Levi, R. (1998). Quality of life and traumatic spinal cord injury. *Arch.Phys.Med.Rehabil.* **79**, 1433-1439.

Whiteneck, G. G. (1994). The 44th annual John Stanley Coulter Lecture. Measuring what matters: key rehabilitation outcomes. *Arch.Phys.Med.Rehabil.* **75**, 1073-1076.

Wirz, M., Colombo, G., & Dietz, V. (2001). Long term effects of locomotor training in spinal humans. *J.Neurol.Neurosurg.Psychiatry* **71**, 93-96.

Wood-Dauphinee, S. & Küchler, T. Quality of Life as a Rehabilitation Outcome: Are we missing the Boat? *Can.J.Rehabil.* **6**[1], 3-12. 1992.

World Health Organization (1980). *International classification of impairments, disabilites, and handicaps: a manual of classification relating to the consequences of disease* Geneva, Switzerland.

Yarkony, G. M., Roth, E. J., Cybulski, G., & Jaeger, R. J. (1992). Neuromuscular stimulation in spinal cord injury: I: Restoration of functional movement of the extremities. *Arch.Phys.Med.Rehabil.* **73**, 78-86.

Yu, D. (1998). A crash course in spinal cord injury. *Postgrad.Med.* **104**, 109-6, 119.

Ziegelstein, R. C., Fauerbach, J. A., Stevens, S. S., Romanelli, J., Richter, D. P., & Bush, D. E. (2000). Patients with depression are less likely to follow recommendations to reduce cardiac risk during recovery from a myocardial infarction. *Arch Intern.Med.* **160**, 1818-1823.

APPENDIX A:

RAW DATA

- Exercise Compliance (12-Month Program) and Adherence (Follow-Up Period)
- Functional Ambulation
- Satisfaction With Life Scale
- Instrumental Activities of Daily Living Questionnaire
- SF-36 – Perceptions of Health Items
- Centre for Epidemiological Studies – Depression
- Change scores and Percent Change Scores for Satisfaction with Life and HRQL Measures

BWSTT COMPLIANCE DURING THE 12-MONTH PROGRAM

Participant	Total days	Possible BWSTT days	Actual BWSTT days	%days BWSTT of total	%days BWSTT of possible
FP	504	216	144	28.6%	66.7%
CC	413	177	144	34.9%	81.4%
TS	455	195	144	31.6%	73.8%
GC	490	210	144	29.4%	68.6%
DH	420	180	144	34.3%	80.0%
JL	406	174	144	35.5%	82.8%
RM	483	207	144	29.8%	69.6%
KD	392	168	144	36.7%	85.7%
CW	448	192	144	32.1%	75.0%
BT	427	183	144	33.7%	78.7%
MS	399	171	144	36.1%	84.2%
PR	399	171	144	36.1%	84.2%
Mean (SD)	436 (39.0)	187 (16.7)	144 (0.0)	33.2 (2.9)%	77.5 (6.7)%

BWSTT OR FITNESS TRAINING ADHERENCE DURING THE FOLLOW-UP PERIOD

Participant	Total days	BWSTT				Fitness Training			
		Possible BWSTT days	Actual BWSTT days	%days BWSTT of total	%days BWSTT of possible	Possible Fintess days	Actual Fitness days	%days Fitness of total	%days Fitness of possible
FP	280	40	0	0.0%	0.0%	80	0	0.0%	0.0%
CC	245	35	11	4.5%	31.4%	70	22	9.0%	31.4%
TS	287	41	9	3.1%	22.0%	82	0	0.0%	0.0%
GC	252	36	23	9.1%	63.9%	72	51	20.2%	70.8%
DH	252	36	2	0.8%	5.6%	72	2	0.8%	2.8%
JL	252	36	9	3.6%	25.0%	72	41	16.3%	56.9%
RM	259	37	9	3.5%	24.3%	74	48	18.5%	64.9%
KD	273	39	15	5.5%	38.5%	78	0	0.0%	0.0%
CW	259	37	0	0.0%	0.0%	74	0	0.0%	0.0%
BT	245	35	29	11.8%	82.9%	70	46	18.8%	65.7%
MS	266	38	25	9.4%	65.8%	76	0	0.0%	0.0%
PR	238	34	7	2.9%	20.6%	68	0	0.0%	0.0%
Mean (SD)	259 (14.9)	37 (2.1)	11.6 (9.7)	4.5 (3.8)%	31.7 (26.8)%	74 (4.3)	17.5 (22.4)	7.0 (8.9)%	24.4 (31.1)%

EXERCISE ADHERENCE DURING THE FOLLOW-UP PERIOD (BWSTT + FITNESS T

Participant	Total days	Possible Exercise days	Actual Exercise days	%days Exercise of total	%days Exercise of possible
FP	280	120	0	0.0%	0.0%
CC	245	105	33	13.5%	31.4%
TS	287	123	9	3.1%	7.3%
GC	252	108	74	29.4%	68.5%
DH	252	108	4	1.6%	3.7%
JL	252	108	50	19.8%	46.3%
RM	259	111	57	22.0%	51.4%
KD	273	117	15	5.5%	12.8%
CW	259	111	0	0.0%	0.0%
BT	245	105	75	30.6%	71.4%
MS	266	114	25	9.4%	21.9%
PR	238	102	7	2.9%	6.9%
Mean (SD)	259 (14.9)	111 (6.4)	29.1 (28.3)	11.5 (11.3)%	26.8 (26.5)%

FUNCTIONAL AMBULATION DATA - BASELINE

Participant	BWSTT				Overground Walking		
	BW (kg)	BWS (kg)	%BWS (%)	Speed (km/h)	Score	Time (min)	Distance (m)
FP	N/A	N/A	N/A	N/A	8	3:14	18.5
CC	94.7	64	67.6%	1.0	7	7:00	59.4
TS	86.2	56	65.0%	0.3	0	N/A	N/A
GC	60.6	48	79.2%	0.5	0	N/A	N/A
DH	96.6	80	82.8%	0.1	0	N/A	N/A
JL	63.0	40	63.5%	0.4	0	N/A	N/A
RM	60.8	32	52.6%	0.1	0	N/A	N/A
KD	53.0	40	75.5%	1.0	0	N/A	N/A
CW	75.7	56	74.0%	0.9	0	N/A	N/A
BT	65.9	56	85.0%	0.5	0	N/A	N/A
MS	74.5	64	85.9%	0.3	0	N/A	N/A
PR	65.5	48	73.3%	0.5	0	N/A	N/A
Mean (SD)	72.4 (14.6)	53.1 (13.5)	73.1 (10.3)%	0.5 (0.3)	1.2 (2.9)	N/A	N/A

FUNCTIONAL AMBULATION DATA - 12-MONTHS

Participant	BWSTT				Overground Walking		
	BW (kg)	BWS (kg)	%BWS (%)	Speed (km/h)	Score	Time (min)	Distance (m)
FP	N/A	N/A	N/A	N/A	9	6:43	29.7
CC	98.4	24	24.4%	1.8	7	51:29	594.0
TS	82.9	0	0.0%	1.1	0	N/A	N/A
GC	63.1	0	0.0%	1.1	0	N/A	N/A
DH	100.5	32	31.8%	0.9	0	N/A	N/A
JL	63.6	11.6	18.2%	0.9	0	N/A	N/A
RM	61.3	16	26.1%	0.8	4	2:32	10.0
KD	62.2	8	12.9%	3.8	7	7:25	118.8
CW	70.8	27.6	39.0%	1.3	0	N/A	N/A
BT	64.3	16	24.9%	1.3	0	N/A	N/A
MS	80.4	10.7	13.3%	1.1	0	N/A	N/A
PR	68.5	16	23.4%	1.5	0	N/A	N/A
Mean (SD)	74.2 (14.4)	14.7 (10.3)	19.5 (12.2)%	1.4 (0.8)	2.2 (3.5)	N/A	N/A

FUNCTIONAL AMBULATION DATA - FOLLOW-UP

Participant	BWSTT				Overground Walking		
	BW (kg)	**BWS (kg)**	**%BWS (%)**	**Speed (km/h)**	**Score**	**Time (min)**	**Distance (m)**
FP	N/A	N/A	N/A	N/A	8	6:50	118.8
CC	100.4	32	31.9%	2.5	7	4:00	33.8
TS	81.9	16	19.5%	1.2	0	N/A	N/A
GC	62.7	16	25.5%	1.1	0	N/A	N/A
DH	101.8	48	47.2%	0.5	0	N/A	N/A
JL	63.6	8	12.6%	0.9	0	N/A	N/A
RM	61.1	24	39.3%	0.8	4	4:25	17.1
KD	62.2	24	38.6%	3.0	7	7:09	178.2
CW	71.9	48	66.8%	1.3	0	N/A	N/A
BT	63.5	24	37.8%	0.9	0	N/A	N/A
MS	80.3	24	29.9%	1.0	0	N/A	N/A
PR	68.5	24	35.0%	1.9	0	N/A	N/A
Mean (SD)	74.4 (15.0	26.2 (12.4)	34.9 (14.4)%	1.4 (0.8)	2.2 (3.3)	N/A	N/A

SATISFACTION WITH LIFE SCALE (SWLS)

Each item is rated from 1 (strongly disagree) to 7 (strongly agree)
Total scores range from 5 (low satisfaction) to 35 (high satisfaction)

BASELINE DATA

Participant	Item					Total
	1	2	3	4	5	
FP	5	5	6	4	2	**22**
CC	7	7	7	7	1	**29**
TS	5	5	5	5	4	**24**
GC	2	1	3	2	2	**10**
DH	6	6	6	6	4	**28**
JL	3	4	3	3	3	**16**
RM	5	6	6	5	6	**28**
KD	2	2	2	3	7	**16**
CW	2	3	5	5	1	**16**
BT	2	2	2	2	1	**9**
MS	1	1	4	1	1	**8**
Mean (SD)	3.6 (2.0)	3.8 (2.1)	4.5 (1.8)	3.9 (1.9)	2.9 (2.1)	**18.7 (7.9)**

12-MONTH DATA

Participant	Item					Total
	1	2	3	4	5	
FP	6	6	6	5	5	**28**
CC	7	7	7	7	7	**35**
TS	6	6	6	5	5	**28**
GC	2	5	6	6	3	**22**
DH	5	6	6	6	3	**26**
JL	2	2	2	4	3	**13**
RM	6	6	5	5	4	**26**
KD	6	6	6	5	2	**25**
CW	6	6	6	7	1	**26**
BT	1	1	3	1	1	**7**
MS	5	4	5	4	3	**21**
Mean (SD)	4.7 (2.0)	5.0 (1.9)	5.3 (1.5)	5.0 (1.7)	3.4 (1.8)	**23.4 (7.6)**

SATISFACTION WITH LIFE SCALE (CON'T)

FOLLOW-UP DATA

Participant	**Item**					**Total**
	1	**2**	**3**	**4**	**5**	
FP	3	5	5	3	2	**18**
CC	7	7	7	7	7	**35**
TS	6	6	6	5	5	**28**
GC	2	2	3	6	2	**15**
DH	6	5	6	5	3	**25**
JL	4	3	3	3	3	**16**
RM	6	6	6	5	6	**29**
KD	6	7	6	4	7	**30**
CW	5	5	6	7	5	**28**
BT	1	1	3	2	2	**9**
MS	2	2	3	4	1	**12**
Mean (SD)	4.4 (2.1)	4.5 (2.1)	4.9 (1.6)	4.6 (1.6)	3.9 (2.2)	**22.3 (8.6)**

INSTRUMENTAL ACTIVITIES OF DAILY LIVING (IADL)

Each item is rated from 0 (Unable to do at all) to 2 (No help needed)
Total scores range from 0 (dependence) to 16 (independence)

BASELINE DATA

Participant	**Item**								**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
FP	2	2	1	1	1	0	2	2	**11**
CC	2	0	2	2	1	2	2	2	**13**
TS	2	2	2	2	1	1.5	2	2	**14.5**
GC	2	2	1	2	1	1	2	2	**13**
DH	2	1	1	1	1	1	2	2	**11**
RM	2	2	1	2	1	1	2	2	**13**
KD	2	2	2	2	2	1	2	0	**13**
CW	2	1	2	1	2	2	2	2	**14**
BT	2	1	1	1	1	0	1	2	**9**
MS	2	1	1	2	2	2	2	2	**14**
Mean (SD)	2.0 (0.0)	1.4 (0.7)	1.4 (0.5)	1.6 (0.5)	1.3 (0.5)	1.2 (0.7)	1.9 (0.3)	1.8 (0.6)	**12.6 (1.7)**

INSTRUMENTAL ACTIVITIES OF DAILY LIVING QUESTIONNAIRE (con't)

12-MONTH DATA

Participant	**Item**								**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
FP	2	2	2	2	1	2	2	2	**15**
CC	2	2	2	2	2	1	2	2	**15**
TS	2	2	1	2	1	2	2	2	**14**
GC	2	2	1	2	1	1	2	2	**13**
DH	2	1	1	1	1	1	2	2	**11**
RM	2	2	2	2	1	2	2	2	**15**
KD	2	2	2	2	2	2	2	0	**14**
CW	2	2	2	2	2	2	2	2	**16**
BT	1	1	1	0	1	0	1	2	**7**
MS	2	1	1	2	2	2	2	2	**14**
Mean (SD)	1.9 (0.3)	1.7 (0.5)	1.5 (0.5)	1.7 (0.7)	1.4 (0.5)	1.5 (0.7)	1.9 (0.3)	1.8 (0.6)	**13.4 (2.6)**

INSTRUMENTAL ACTIVITIES OF DAILY LIVING QUESTIONNAIRE (con't)

FOLLOW-UP DATA

Participant	**Item**								**Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
FP	2	2	2	2	1	2	2	2	**15**
CC	2	2	2	2	1	2	2	2	**15**
TS	2	2	1	1	1	1	2	2	**12**
GC	2	2	2	2	1	1	2	2	**14**
DH	2	1	1	1	1	1	2	2	**11**
RM	2	2	2	2	1	2	2	2	**15**
KD	2	2	2	2	2	2	2	0	**14**
CW	2	2	2	2	2	1	2	2	**15**
BT	2	1	1	1	1	1	1	2	**10**
MS	2	2	1	2	2	2	2	2	**15**
Mean (SD)	2.0 (0.0)	1.8 (0.4)	1.6 (0.5)	1.7 (0.5)	1.3 (0.5)	1.5 (0.5)	1.9 (0.3)	1.8 (0.6)	**13.6 (1.9)**

SF-36 - PERCEPTIONS OF HEALTH ITEMS

Each item is rated from 1 (Poor) to 5 (Excellent)
The average score ranges from 1 (Poor health perception) to 5 (Excellent health perception)

BASELINE DATA

Participant	Item		Average
	1	2	
FP	4	4	**4**
CC	3	5	**4**
TS	5	3	**4**
GC	2	4	**3**
DH	4	3	**3.5**
JL	4	5	**4.5**
RM	4	3	**3.5**
KD	4	5	**4.5**
CW	5	5	**5**
BT	4	5	**4.5**
MS	4	3	**3.5**
Mean (SD)	3.9 (0.8)	4.1 (0.9)	**4.0 (0.6)**

12-MONTH DATA

Participant	Item		Average
	1	2	
FP	4	5	**4.5**
CC	4	5	**4.5**
TS	5	5	**5**
GC	4	2	**3**
DH	4	3	**3.5**
JL	3	4	**3.5**
RM	5	5	**5**
KD	5	3	**4**
CW	5	5	**5**
BT	4	5	**4.5**
MS	4	4.5	**4.25**
Mean (SD)	4.3 (0.6)	4.2 (1.1)	**4.2 (0.7)**

SF-36 - PERCEPTIONS OF HEALTH ITEMS (con't)

FOLLOW-UP DATA

Participant	Item		Average
	1	2	
FP	3	5	**4**
CC	5	5	**5**
TS	4	5	**4.5**
GC	4	5	**4.5**
DH	3	3	**3**
JL	3	4	**3.5**
RM	5	5	**5**
KD	4	2	**3**
CW	4	5	**4.5**
BT	3	4	**3.5**
MS	4	4	**4**
Mean (SD)	3.8 (0.8)	4.3 (1.0)	**4.0 (0.7)**

CENTRE FOR EPIDEMIOLOGICAL STUDIES - DEPRESSION (CES-D)

Each item is rated from 0 (rarely or none of the time) to 3 (all of the time)

Total scores range from 0 (no depressive symptomatology) to 60 (high depressive symptomatology); > 15 is high-risk

Items 4, 8, 12, and 16 have been reverse-scored (0=3, 1=2, 2=1, 3=0)

BASELINE DATA

Participant	ITEMS																				TOTAL
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
FP	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	**2**
CC	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
TS	0	0	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	**5**
GC	0	0	0	0	0	0	1	0	1	0	0	2	2	2	2	0	0	1	0	0	**11**
DH	0	0	0	0	0	1	2	1	0	1	0	0	1	0	0	1	0	1	0	0	**8**
JL	0	0	1	1	1	1	0	1	0	0	2	2	0	1	0	1	0	0	0	0	**11**
RM	0	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	0	0	0	1	**7**
KD	0	1	0	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	**8**
CW	0	0	1	1	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	**6**
BT	1	0	1	1	1	1	1	0	1	1	0	2	0	1	0	2	0	1	1	0	**15**
MS	0	0	1	1	0	0	1	1	1	1	2	1	0	1	1	1	0	0	0	0	**12**
Mean (SD)	0.1	0.1	0.5	0.4	0.5	0.3	1.3	0.6	0.3	0.3	0.5	0.7	0.3	0.5	0.3	0.5	0.0	0.3	0.1	0.4	**7.8 (4.3)**

CENTRE FOR EPIDEMIOLOGICAL STUDIES - DEPRESSION (CON'T)

12-MONTH DATA

Participant	ITEMS																				TOTAL
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
FP	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	**4**
CC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TS	1	0	0	0	0	1	1	0	0	0	0	0	2	2	0	0	0	1	0	1	**9**
GC	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	**3**
DH	0	0	0	1	1	0	2	1	0	0	1	1	0	0	1	0	0	1	1	0	**10**
JL	1	0	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	1	0	**14**
RM	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**2**
KD	0	1	0	0	2	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	**7**
CW	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**
BT	1	0	0	1	0	1	2	0	1	1	0	0	1	1	0	2	0	1	0	0	**12**
MS	1	2	0	1	0	0	0	2	1	0	2	1	1	1	1	1	0	0	0	1	**15**
Mean (SD)	0.4	0.4	0.0	0.4	0.5	0.3	1.0	0.5	0.2	0.1	0.5	0.3	0.5	0.5	0.4	0.4	0.0	0.5	0.2	0.3	**7.3 (5.0)**

CENTRE FOR EPIDEMIOLOGICAL STUDIES - DEPRESSION (CON'T)

FOLLOW-UP DATA

Participant	ITEMS																				TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
FP	1	0	0	0	0	0	1	0	0	0	1	1	1	1	0	1	0	1	0	1	**9**
CC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TS	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	**4**
GC	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	**3**
DH	1	0	0	0	1	0	2	1	0	1	1	1	0	1	0	1	0	1	0	0	**11**
JL	0	2	1	0	1	0	1	2	0	0	1	2	1	1	0	0	0	1	0	1	**14**
RM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
KD	0	1	0	0	1	0	1	0	0	0	0	1	0	0	1	0	1	1	0	1	**8**
CW	0	0	0	0	0	0	3	2	0	0	0	0	1	0	0	0	0	0	0	0	**6**
BT	1	0	0	0	0	1	1	0	1	1	0	0	1	1	0	1	0	0	0	0	**8**
MS	1	2	1	1	3	1	1	1	0	0	3	2	2	1	0	1	0	2	0	3	**25**
Mean (SD)	0.4	0.5	0.2	0.1	0.6	0.2	1.0	0.5	0.1	0.2	0.7	0.7	0.6	0.5	0.1	0.4	0.1	0.5	0.0	0.6	**8.1 (7.0)**

CHANGE SCORES AND PERCENT CHANGE SCORES FOR EACH HRQL MEASURE

Change score = Follow-up score - 12-month score

%Change score = (Follow-up score - 12-month score)/12-month score

Participant	SWLS		IADL		SF-36		CES-D	
	Change	%Change	Change	%Change	Change	%Change	Change	%Change
FP	-10	-35.7%	0	0.0%	-0.5	-11.1%	5	125.0%
CC	0	0.0%	0	0.0%	0.5	11.1%	0	0.0%
TS	0	0.0%	-2	-14.3%	-0.5	-10.0%	-5	-55.6%
GC	-7	-31.8%	1	7.7%	1.5	50.0%	0	0.0%
DH	-1	-3.8%	0	0.0%	-0.5	-14.3%	1	10.0%
JL	3	23.1%	N/A	N/A	0	0.0%	0	0.0%
RM	3	11.5%	0	0.0%	0	0.0%	-1	-50.0%
KD	5	20.0%	0	0.0%	-1	-25.0%	1	14.3%
CW	2	7.7%	-1	-6.3%	-0.5	-10.0%	2	50.0%
BT	2	28.6%	3	42.9%	-1	-22.2%	-4	-33.3%
MS	-9	-42.9%	1	7.1%	-0.25	-5.9%	10	66.7%

APPENDIX B:

STATISTICAL ANALYSIS OUTPUT

- Analysis for Intervention Effect
- Analysis for differences between pre-training, 12-months, and follow-up %BWS
- Analysis for differences between pre-training, 12-months, and follow-up preferred treadmill speed
- Analysis for differences between pre-training, 12-months, and follow-up overground walking score
- Analysis for correlation between individual changes in %BWS and % of possible BWSTT sessions attended during follow-up
- Analysis for correlation between individual changes in %BWS and %BWS at 12-months
- Reliability Data for All Multi-Item Outcome Measures at Baseline, 12-months, and Follow-up
- Analysis for differences between pre-training, 12-months, and follow-up scores on the Satisfaction With Life Scale
- Analysis for differences between pre-training, 12-months, and follow-up scores on the Instrumental Activities of Daily Living scale
- Analysis for differences between pre-training, 12-months, and follow-up scores on SF-36: Perceptions of Health items
- Analysis for differences between pre-training, 12-months, and follow-up scores the Centre for Epidemiological Studies Depression scale
- Correlations between scores on all psychological measures at 12-months
- Correlations between scores on all psychological measures at Follow-up
- Correlations between percent change scores on all psychological measures (12-months to follow-up) and exercise adherence during the follow-up period (BWSTT+Wheelers)

Analysis for differences between pre-training, 12-months, and follow-up %BWS

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	.839507	20	.009837	85.34384	.000000**

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	.7311891 (Pre-training)	.1945140 (12-months)	.3490917 (Follow-up)
.7311891		.000145**	.000145**
.1945140	.000145**		.004399**
.3490917	.000145**	.004399**	

Analysis for differences between pre-training, 12-months, and follow-up preferred treadmill speed

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	2.886364	20	.145030	19.90180	.000017**

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	.5090909 (Pre-training)	1.418182 (12-months)	1.372727 (Follow-up)
.5090909		.000184**	.000224**
1.418182	.000184**		.957913
1.372727	.000224**	.957913	

Analysis for differences between pre-training, 12-months, and follow-up overground walking score

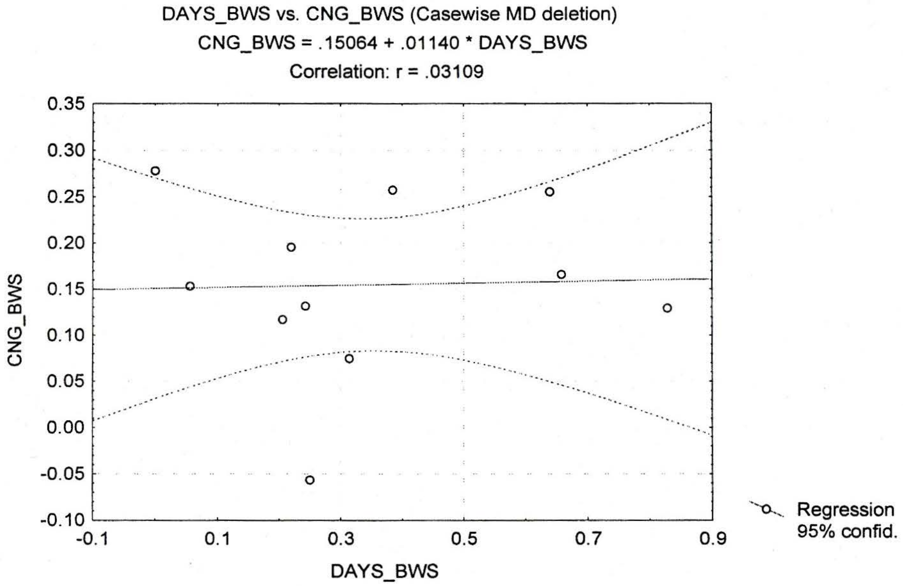
Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	4.527778	22	1.709596	2.648449	.093197

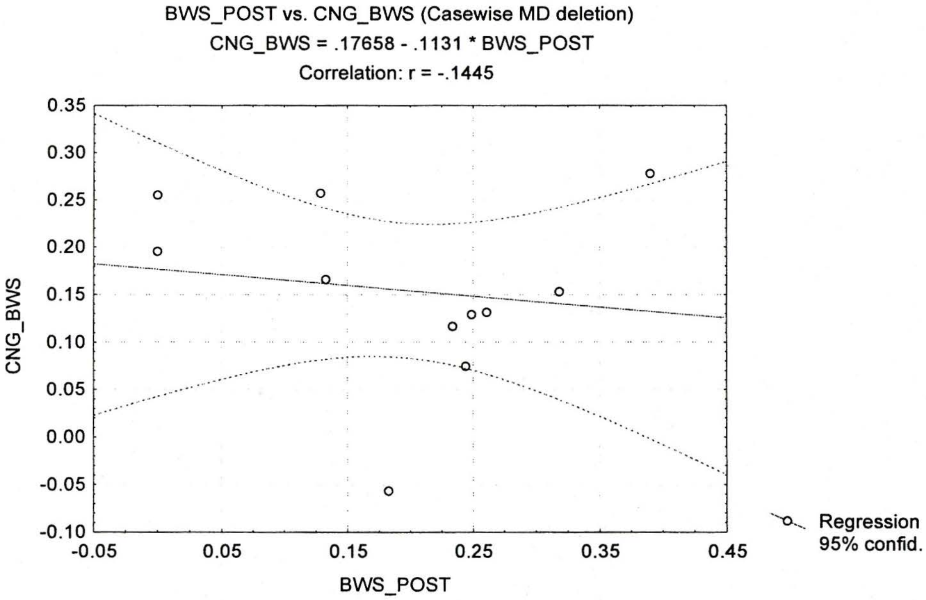
Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	1.250000 (Pre-training)	2.416667 (12-months)	2.166667 (Follow-up)
1.250000		.096096	.221395
2.416667	.096096		.886798
2.166667	.221395	.886798	

Analysis for correlation between individual changes in %BWS and % of possible BWSTT sessions attended during follow-up



Analysis for correlation between individual changes in %BWS and %BWS at 12-months



CNG_BWS = Change in %BWS from 12-months to follow-up
DAYS_BWS = % of possible BWSTT sessions that were attended during follow-up
BWS_FOL = %BWS at 12-months

Reliability Data for All Multi-Item Outcome Measures at Baseline, 12-months, and Follow-up

	Baseline α	12-month α	Follow-up α
Perceived Quality of Life Scale	.88	.90	.91
Satisfaction With Life Scale	.86	.91	.93
Instrumental Activities of Daily Living	N/A	.76	N/A
Centre for Epidemiological Studies Depression Scale	N/A	N/A	N/A

N/A = Chronbach alpha value could not be calculated due to non-variance in one or more items.

Analysis for differences between pre-training, 12-months, and follow-up scores on the Satisfaction With Life Scale

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	64.63636	20	15.93636	4.055904	.033221*

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	18.72727 (Pre-training)	23.36364 (12-months)	22.27273 (Follow-up)
18.72727		.033630*	.118973
23.36364	.033630*		.799640
22.27273	.118973	.799640	

Analysis for differences between pre-training, 12-months, and follow-up scores on the Instrumental Activities of Daily Living scale

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	3.108333	18	1.219444	2.548975	.105997

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	12.55000 (Pre-training)	13.40000 (12-months)	13.60000 (Follow-up)
12.55000		.224812	.112597
13.40000	.224812		.914071
13.60000	.112597	.914071	

Analysis for differences between pre-training, 12-months, and follow-up scores on SF-36: Perceptions of Health items

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	.195076	20	.345076	.565313	.577001

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	4.000000 (Pre-training)	4.250000 (12-months)	4.045455 (Follow-up)
4.000000		.586600	.982114
4.250000	.586600		.697380
4.045455	.982114	.697380	

Analysis for differences between pre-training, 12-months, and follow-up scores the Centre for Epidemiological Studies Depression scale

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	1.909091	20	11.57576	.164921	.849102

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: TRAINING)

TIME	7.818182 (Pre-training)	7.272727 (12-months)	8.090909 (Follow-up)
7.818182		.925415	.980810
7.272727	.925415		.840616
8.090909	.980810	.840616	

Correlations between scores on all psychological measures at 12-months

	SWLS	**IADL**[a]	**SF-36**	**CES-D**
SWLS		r = .811268 r^2 = .658156 p = .004390**	r = .278871 r^2 = .077769 p = .406298	r = -.687523 r^2 = .472688 p = .019392*
IADL[a]	r = .811268 r^2 = .658156 p = .004390**		r = .313072 r^2 = .098014 p = .378424	r = -.555966 r^2 = .309098 p = .095156[t]
SF-36	r = .278871 r^2 = .077769 p = .406298	r = .313072 r^2 = .098014 p = .378424		r = -.238746 r^2 = .056999 p = .479566
CES-D	r = -.687523 r^2 = .472688 p = .019392*	r = -.555966 r^2 = .309098 p = .095156[t]	r = -.238746 r^2 = .056999 p = .479566	

a = correlations were performed with only 10 participants
t = trend
* = <.05
** = <.01

Correlations between scores on all psychological measures at Follow-up

	SWLS	**IADL**[a]	**SF-36**	**CES-D**
SWLS		r = .311914 r^2 = .097291 p = .380285	r = .337243 r^2 = .113733 p = .310481	r = -.591383 r^2 = .349734 p = .055330[t]
IADL[a]	r = .311914 r^2 = .097291 p = .380285		r = .547619 r^2 = .299887 p = .101299[t]	= -.016481 r^2 = .000272 p = .963957
SF-36	r = .337243 r^2 = .113733 p = .310481	r = .547619 r^2 = .299887 p = .101299[t]		r = -.522961 r^2 = .273488 p = .098811[t]
CES-D	r = -.591383 r^2 = .349734 p = .055330[t]	r = -.016481 r^2 = .000272 p = .963957	r = -.522961 r^2 = .273488 p = .098811[t]	

a = correlations were performed with only 10 participants
t = trend

Correlations between percent change scores on all psychological measures (12-months to follow-up) and exercise adherence during the follow-up period (BWSTT+Wheelers)

	%Δ SWLS	**%Δ IADL[a]**	**%Δ SF-36**	**%Δ CES-D**	**Exercise Adherence**
%Δ SWLS		r = .241260 r^2 = .058206 p = .501904	r = -.433978 r^2 = .188337 p = .182329	r = -.610579 r^2 = .372807 p = .04602*	r = .225388 r^2 = .050800 p = .505185
%Δ IADL[a]	r = .241260 r^2 = .058206 p = .501904		r = -.090820 r^2 = .008248 p = .802963	r = -.124550 r^2 = .015513 p = .731734	r = .701065 r^2 = .491493 p = .02390*
%Δ SF-36	r = -.433978 r^2 = .188337 p = .182329	r = -.090820 r^2 = .008248 p = .802963		r = -.097171 r^2 = .009442 p = .776240	r = .486768 r^2 = .236943 p = .128912 [t]
%Δ CES-D	r = -.610579 r^2 = .372807 p = .04602*	r = -.124550 r^2 = .015513 p = .731734	r = -.097171 r^2 = .009442 p = .776240		r = -.511394 r^2 = .261524 p = .107871[t]
Exercise Adherence	r = .225388 r^2 = .050800 p = .505185	r = .701065 r^2 = .491493 p = .02390*	r = .486768 r^2 = .236943 p = .128912 [t]	r = -.511394 r^2 = .261524 p = .107871 [t]	

a = correlations were performed with only 10 participants
t = trend
* = <.05

Analysis for Intervention Effect: Comparing % days spent at the Centre for Health Promotion during the 12-month training period (for BWSTT) and during the follow-up period (for BWSTT and for BWSTT + fitness training)

Analysis with all 12 participants

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	.269186	20	.004071	66.12551	.000000**

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: intervention)

TIME	**.3323528 (% BWSTT during 12-month period)**	**.0452196 (% BWSTT during follow-up period)**	**.1148776 (% BWSTT + Fitness Training during follow-up period)**
.3323528		.000136**	.000136**
.0452196	.000136**		.035653*
.1148776	.000136**	.035653*	

* = <.05
** = <.01

Analysis without PR (was not included in any psych analyses)

Summary of all Effects; design: Repeated-measures ANOVA

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
TIME	2	.236161	18	.004118	57.35447	.000000*

Tukey HSD test; Probabilities for Post Hoc Tests (MAIN EFFECT: intervention)

TIME	**.3297574 (% BWSTT during 12-month period)**	**.0466567 (% BWSTT during follow-up period)**	**.1226472 (% BWSTT + Fitness Training during follow-up period)**
.3297574		.000145**	.000145**
.0466567	.000145**		.030039*
.1226472	.000145**	.030039*	

* = <.05
** = <.01

APPENDIX C:

SATISFACTION WITH LIFE AND HRQL MEASURES

- Satisfaction With Life Scale
- Instrumental Activities of Daily Living
- SF-36: Perceptions of Health Items
- Centre for Epidemiological Studies – Depression

SATISFACTION WITH LIFE SCALE

(SWLS; Diener et al., 1985)

Strongly Disagree	Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. In most ways my life is close to my ideal. ______
2. The conditions of my life are excellent. ______
3. I am satisfied with my life. ______
4. So far I have gotten the important things I want in life. ______
5. If I could live my life over, I would change almost nothing. ______

INSTRUMENTAL ACTIVITIES OF DAILY LIVING

(Lawton, 1982)

The following are questions about how much help you need during activities of daily living. Please check the box that most applies for each activity.

Activity	**No Help**	**Need Some Help**	**Unable To Do At All**
1. Using the telephone			
2. Getting to places beyond wheeling distance			
3. Grocery Shopping			
4. Preparing meals			
5. Doing housework or handyman work			
6. Doing laundry			
7. Taking medications			
8. Managing money			

SHORT-FORM HEALTH SURVEY: PERCEPTIONS OF HEALTH ITEMS

(SF-36; Ware and Sherbourne, 1992)

We are interested in your opinions about your health. Please read each question carefully and mark one box that best describes you. There are no right or wrong answers.

1. In general, would you say your health is:

Excellent	Very Good	Good	Fair	Poor
☐	☐	☐	☐	☐

2. Compared to one year ago, how would you rate your health in general now?

Much Better now	Somewhat better now	About the same	Somewhat worse	Much worse
☐	☐	☐	☐	☐

CENTRE FOR EPIDEMIOLOGICAL STUDIES – DEPRESSION
(CES-D; Radloff, 1977)

Below is a list of some of the ways you may have felt or behaved. Please indicate how often you have felt this way during the **past week** by filling in the appropriate number.

Rarely or none of the time (less than 1 day)	*Some or a little of the time (1-2 days)*	*Occasionally or a moderate amount of the time (3-4 days)*	*All of the time (5-7 days)*
0	**1**	**2**	**3**

1. I was bothered by things that don't usually bother me. _____
2. I did not feel like eating; my appetite was poor. _____
3. I felt that I could not shake off the blues, even with help from my family _____
4. I felt that I was just as good as other people. _____
5. I had trouble keeping my mind on what I was doing. _____
6. I felt depressed. _____
7. I felt that everything I did was an effort. _____
8. I felt hopeful about the future. _____
9. I thought my life had been a failure. _____
10. I felt fearful. _____
11. My sleep was restless. _____
12. I was happy. _____
13. I talked less than usual. _____
14. I felt lonely. _____
15. People were unfriendly. _____
16. I enjoyed life. _____
17. I had crying spells. _____
18. I felt sad. _____
19. I felt that people disliked me. _____
20. I could not get "going". _____