CHAPTER 3

REVIEW

OF

SCIENTIFIC LITERATURE

3.0 REVIEW OF SCIENTIFIC LITERATURE

Spinal cord injury (SCI) is a catastrophic event which is sudden and unexpected that can affect the patient's normal sensory, motor and autonomic function, leading to dependency, morbidity and deterioration in mental health and quality of life (Cieza, Sabariego, Bickenbach, & Chatterji, 2018;Sekhon & Fehlings, 2001).

3.1 EPIDEMIOLOGY OF SCI

In epidemiology, the numbers giving an extent of paraplegia versus tetraplegia have changed contrasted with earlier studies. 66% of SCI patients have paraplegia, and 33% is tetraplegic while in previous studies, the extent of people with paraplegia used to be up to 90%, as shown by literature data. A very high percentage ofpeople with tetraplegia were found in the investigation from the Netherlands (57%). Jackson et al., in their demographic study,report a tetraplegia percentage of 54.1% in the United States. Before 30 years, 40% of SCI patients had a complete lesion. Recent studies show an increase in complete SCI to half.

Aside from Portugal and Taiwan, the mean period of patients supporting their injury is in their early thirties. The NSCISC(National Spinal Cord Injury Statistical Centre)truth sheet expresses that from 1973 to 1979, the normal age at damage was 28.7 years and that it has ascended to 37.6 years in 2000 (Jackson, Dijkers, Devivo, & Poczatek, 2004).The sex distribution (men/women) of SCI in recent studies is 3.8/1, where it used to be 4.8/1. Men seem to be still more at risk for SCI; however, women do seem to catch up slowly.

The conclusion is that most patients with SCI are young men, at the beginning of their thirties, more likely paraplegic, complete or incomplete. This has severe socio-economic consequences. Most of these men will be working to support their families. With an SCI, they will have to rely on help from the health care system, and on the social security system; some of them for the rest of their lives. Others will have to switch jobs, with or without additional training. It is a big change in their own lives, but as they are at the mean productive age, it also influences the economic and social structure of the society they live in.

The expansion in the level of people with tetraplegia and the increment in level of complete injuries are noted in all the accessible examinations. As revealed previously, these two variables may, together with more seasoned age at damage, impact survival time. Tetraplegic patients require more consideration and have incredible troubles changing over to another activity. An Australian investigation anticipated that populace development and maturing and expanding rates of SCI in the old will affect the normal number of SCI patients and their case blend. It anticipated a 143% expansion in the quantity of instances of deficient tetraplegia, from 88 cases for every annum in 1997 to 214 cases for each annum in 2021.

3.2 SCI INCIDENCE AND PREVALENCE

SCI leads to immense economic burden on the country's health care system(Lee et al., 2013; Singh et al., 2014).The true impact of SCI can be reflected through the average prevalence rate of 1:1000, and the mean incidence estimated to be between 4 and 9 cases per 100,000 populations per year worldwide(Thietje, 2017).A study reported that road traffic accidents, brutality/violence, and falls are the most common causes of traumatic SCI, whereas the leading causes of non-traumatic SCI (NTSCI) are degenerative disorders, tumors and infectious diseases such as tuberculosis and HIV. It was also reported that the gender ratio in traumatic SCI is 3:1 (men:women), whereas gender is equally distributed in non-traumatic SCI (Lee et al., 2013).

3.3 BARRIERS IN NEURONAL REGENERATION/FUNCTIONAL RECOVERY IN SCI

Inflammation: Inflammation leads to apoptosis of neurons and oligodendrocytes, scar formation, and finally in the reduction of neuronal function. Managing inflammation will decrease secondary degeneration and the functional deficit after SCI(Gazdic et al., 2018).

Secondary Infections: Urinary tract infection, pressure ulcers, pulmonary and cardiovascular problems are some SCI complications which cause psychosocial distress for patients and delay of integration with society(Magia, Bhise, Prabhakar, & Shukla, 2015).

Chronic Pain Syndrome: Chronic pain in SCI is mostly referred to as 'central pain' and is very debilitating in nature and results in poor rehabilitation outcomes(Lee, Zhao, Hatch, Chun, & Chang, 2013).

Respiratory Failure and Fatigue: Respiratory complications remain the most common cause of mortality following SCI(Magia et al., 2015).

3.4 SCI AND CHRONIC INFLAMMATION

The International Standards examination used for neurological classification of SCI assesses the severity and extent of injury. American Spinal Injury Association (ASIA) Impairment Scale (AIS) classifies SCI into five levels ranging from complete neurological function which is loss at the site, and below the level of injury. Thus, the neurological level of injury decides the functional goals of rehabilitation(Kirshblum et al., 2011).

Management of acute TSCI involves surgery followed by long term rehabilitation to improve functional abilities and Quality of Life (QoL). However, evidence shows that chronic SCI is found to be associated with systemic inflammation. A study found raised

CRP in chronic SCI patients even without the evidence of any concurrent infections, which is an indicator of systemic inflammation (Gibson, Buchholz, & Martin Ginis, 2008). Systemic inflammation in patients with the SCI is associated with poor rehabilitation outcomes which eventually affects improvement in QoL following rehabilitation(Frost, Roach, Kushner, & Schreiber, 2005; Gibson, Buchholz, & Martin Ginis, 2008; Wang et al., 2007). Any interventionwhich reduces systemic inflammation can be a significant contributor in improving rehabilitation outcome.

3.5 SCI AND SENSORY-MOTOR IMPAIRMENT

SCI also leads to loss of walking function and functional independence due to impaired sensation, decrease in muscle power, and spasticity (Ness & Field-Fote, 2009). Functional recovery helps to boost self-esteem and improve cognitive function (Davidoff, Roth, Haughton, & Ardner, 1990).

3.6 SCI AND RISK OF OBESITY

Increased body mass index (BMI) in SCI is associated with an increased risk of cardiovascular disease (CVD). BMI has been used in earlier studies as a stand-in predictor of risk of obesity in individuals with SCI (Buchholz & Bugaresti, 2005; Gorgey, Gater, et al., 2007).

3.7 SCI AND PSYCHOLOGICAL DISTRESS

Patients with SCI often experience post-traumatic stress disorder and distress, which are associated with decreased compliance with rehabilitation. Prevalence of other co-morbidities such as emotional distress, psychological issues, and post-traumatic stress disorders (PTSD) is very high, which adjusts activities of daily living (ADL) very poor (Nicotra, Critchley, Mathias, & Dolan, 2006).

3.8 YOGAAS A THERAPEUTIC TOOL

Yoga is a promising mind-body intervention for improving health and well- being in a number of able-bodied and clinical populations(Gnecchi, Danieli, & Cervio, 2012).It is an ancient Indian physical, mental, and spiritual practice,and the word “yoga” comes from Sanskrit, “*yuj*,” meaning “yoke” or “union”(Smith & Boser, 2013). Yoga has been observed to treat symptoms of some neurological and psychiatric disorders through anarray of physiological mechanisms pertinent to either the aerobic factors of yoga (the changing sequel of asanas) or the breathing and meditative components of yoga (pranayama and dhyana). The aerobic components of yoga augment mental health through a variety of pathways such as stimulating the central nervous system for the release of endorphinsmonoamines, and brain-derived neurotrophic factor (BDNF) in the hippocampus (Victor & Gottlieb, 2002). The meditative part consists of controlled breathing, relaxation, and meditation techniques and works with multiple possible mechanisms, which lead to a decrement in sympathetic and increase in parasympathetictone, which further has been linked withemotional regulation and empathic response(Smith E, 2013). Secondly, there may be increase in heart-rate variability (HRV) and respiratory sinus arrhythmia (RSA). The reduction in these parameters has been associated with anxiety, panicdisorder, depression, irritable bowel syndrome, early Alzheimer’s, and obesity. Finally, meditative practices lead to increases in EEG synchrony and coherence, which are associated with improved integrated brain functioning and problem-solving.

Various studies show that meditation increases the levels of Brain-derived neurotrophic factor (BDNF) (Xiong & Doraiswamy, 2009). Other consequences includean increase in vagal tone, down-regulation of the hypothalamic-pituitary-adrenal axis and decrease in serum cortisol, increase in gamma-aminobutyric acid (GABA) levels and serum prolactin.

Upgrading of frontal electroencephalogram (EEG), alpha wave activity, improves relaxation(Janakiramaiah et al., n.d.; Park et al., 2008; Chris C. Streeter et al., 2010). Some studies have linked an increase in melatonin and a decreasein cortisol, to the meditative components of yoga (Jaglal et al., 2009). Increases in melatonin impact promotion of sleep stimulates the immune system by acting as a powerful antioxidant and decreases blood pressure. Further, Tooley et al. observed higher levels of plasma melatonin inpatients immediatelyafter yogic meditation sessions, as compared with control (Taguchi et al., 2004). They hypothesized two possible mechanisms: First, meditation reduces blood flowto the liver, slowing the metabolism of melatonin. Secondly,these practices increase the levels of serotonin, which is converted tomelatonin in the pineal gland. Harinath et al. also observed an increase in melatonin levels after a 3-month practice of asanas, pranayama, and meditation. Meditation has also been associated with reduction in levels of cortisol. Studies have found a significant positive correlation between levels of cortisol, negative affect, and depression. Vagal or parasympathetic activity is responsible for calming the body's stress response systems and is associated with decreased levels of cortisol. Thus, components of yoga apart from aerobic exercises, such as controlled breathing and meditation techniques, is known to decrease cortisol levels (Hitzig et al., 2014; Pal, Singh, Chatterjee, & Saha, 2014)More active practices followed by relaxing ones lead to deeper relaxation than relaxing practices alone, documented by research from Swami Vivekananda Yoga University, Bangalore, India and possibility of neural plasticity bringing changes in the hypo-pituitary–pancreatic axis (Zhang, Yin, Xu, Wu, & Chen, 2012).

3.9 NEUROPSYCHIATRIC ILLNESSES AND YOGA THERAPY

A review reported that psychopharmacology is a foundation treatment method for the management of neurological and psychiatric disorders. But they are associated with metabolic side effects such as weight gain, diabetes, and dyslipidaemias, and cardiovascular and sexual dysfunction. Also, therapeutic benefit of these medications is often inadequate (Meyer et al., 2012). Various other studies have proved that yoga and physical therapy (PT) interventions have enhanced recovery in various neuropsychiatric illnesses (Bhargav et al., 2014).Yoga is a form of mind-body intervention comprised of adaptation of specific body poses or *asanas,* breath control, and meditation and it is also a way of life which helps in bringing the harmony at physical, physiological, mental, social and spiritual aspects of individual (Williams et al., 2005).Other scientific studies reported that yoga improves spasticity, gait, and cognition, functional independence, mental health and QoL among patients with neurological disorders (Meyer et al., 2012). Yoga enhances motor and sensory function, ADL, gait, mental flexibility, psychological well-being and relaxation in individuals with SCI (Curtis et al., 2017; Telles et al., 2017; Zwick, 2006). Furthermore, yoga has shown that incorporation of different yogic techniques into rehabilitation protocol of individuals with SCI, with proper guided assistance, is believed to stimulate neural pathways and neurotransmitters (Raju, 2017). This, in turn, can be valuable instrument in the regeneration of nerve fibers in SCI patients (Smith & Boser, 2013).

In a single case study, it was found that Iyengar yoga can easily be incorporated into an exercise program of an individual with SCI and practiced over years has been shown to improve muscle strength, flexibility, coordination and proprioception through stretching of the muscles (Zwick, 2006). However, a large number of studies recommended RCTs to assess the impact of yoga in SCI (Curtis et al., 2017).Thus, there is a clear need for complementary, non-psycho-pharmacological therapy such as yoga which can be an effective adjunctive treatment option for neurological and psychiatric disorders.

Hence, the current study aimed to evaluateefficacy of add on of yoga therapy to conventional rehabilitation of SCI on systemic inflammation,Erythrocyte Sedimentation Rate (ESR), American spinal injury assessment (ASIA) scores, functional independence, gait, spasticity, pain, emotional distress, body mass index (BMI), and quality of life on paraplegics.

3.10 REHABILITATION OF SCI PATIENTS: POTENTIAL OF YOGA

Severed spinal cord due to SCI leads to disruption of communication in parts that are innervated at or below the lesion. Neuroprotective drugssuch as methylprednisolone are being used for thetreatment of spinal injuries and may prevent cell death. SCI is followed by several complications for which there is a need for rehabilitation(Raju, 2017). Teams of nurses, physicians, physical and occupational therapists, psychologists, and social workers, availinterdisciplinary health care services for rehabilitation of SCI patients. Yoga as a therapy is a holistic approach, which is believed to stimulate neural pathways and neurotransmitters. Thus, different yogic techniques may act as a valuable healing tool, with proper modification and supervised facilitation, leading todegeneration of nerve fibers in SCI patients(Park et al., 2008).

Table 4: Summary Table of Scientific Research on SCI.

Author &Year of Publication	N	Design	Variable studied	Findings/Results	Conclusion	Limitations
Eddleetal, 2011	74	Single-blinded RCT.	Over-ground walking speed and distance were the primary outcome measures.	For speed, there were no significant between-group differences; however, distance gains were greatest with OG.	In people with chronic motor incomplete SCI, walking speed improved with both over ground training and treadmill-based training; however, walking distance improved to a greater extent with over ground training.	It is unknown whether the training dosage and the emphasis on training speed were optimal. Robotic training that requires active participation would likely yield different results.
Micheal et al, 1990	162+154+171	It is a multicentre, double-blind, randomized, and placebo-controlled Trial.	Motor and sensory function assessed by Systematic Neurological Examination.	Patients with acute spinal-cord injury, treatment with methylprednisolone in the dose used in this study improves neurologic recovery when the medication is given in the first eight hours, than naloxone.	It was concluded that treatment with naloxone in the dose used in this study does not improve neurologic recovery after acute spinal-cord injury.	1.The present study focused only on neurologic changes after injury and not on any other therapeutic benefits. 2.Residual uncertainty about the safety of extended high-dose therapy is another limitation.
Hicks et al, 2003	34	Randomized controlled trial.	One repetition maximum (1RM) strength, Arm ergometry performance, Several indices of quality of life, And psychological well-being.	Following training, the EX group had significant increases in sub maximal arm ergometry power output (81%; $P<0.05$), and significant increases in upper body muscle strength (19–34%; $P<0.05$); no significant changes occurred in CON. Participants in EX reported significantly less pain and stress. depression after training, and scored higher than CON in indices of satisfaction with physical function, level of perceived health and overall quality	These results demonstrate that long-term twice-weekly exercise training in SCI population is beneficial, and results in significant gains in both physical and psychological well-being.	This study had a 47.6% drop-out by 9 months of training. Secondly, it had a small sample size.

				of life (P<0.05).		
Richardson et al., 2019.	59	Randomized, controlled, single-blinded trial.	Pain outcomes included changes in pain severity across all pain types, NP unpleasantness, and severity of various sensory qualities of NP.	Results from this trial suggest that virtual walking treatment may benefit certain aspects of NP, such as associated unpleasantness, as well as certain sensory qualities of that pain.	The present study concludes that virtual walking treatment benefits certain aspects of NP, such as associated unpleasantness, as well as certain sensory qualities of that pain.	Efficacy of this treatment modality to reduce overall pain severity remains unclear, and may be modulated by other injury, individual, or personality characteristics.
Roth et al, 2010	29	A randomized controlled trial.	Pulmonary function tests: included forced vital capacity (FVC); forced expiratory volume in 1 second (FEV1); maximum expiratory pressure (MEP); maximum inspiratory pressure (MIP); inspiratory capacity (IC); expiratory reserve volume (ERV); total lung capacity (TLC); functional residual capacity (FRC); and residual volume (RV).	FVC, FEV1, and ERV improved in both groups. Although exit values of MEP were improved in both groups compared with entry values, this increase was statistically significant only in the resistance training group. Nosignificant improvements occurred in IC, TLC, FRC, or RV from entry to exit. MIP improved in both groups, but this increase was statistically significant only in the resistance training group.	The resistance training group had significantly greater exit MEP values than the sham training group in univariate analysis only. However, improvements in pulmonary function were noted in both the resistance training and sham training groups.	Multivariate analysis failed to reveal a significant difference between groups.