Physical activity prescription for the prevention of metabolic disease after a spinal cord injury: A systematic review

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I dedicate this paper to my loving Heavenly Father. Thank you dear Lord for your grace, loyalty and unconditional love. Thank you for the opportunities and talents that you have blessed me with.

“He who dwell in the secret place of the Most High shall remain stable and fixed under the shadow of the Almighty” – Ps 91:1

Hereby I would like to thank the following people sincerely for all your contributions and sacrifices to the reality of this dissertation:

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With sincere appreciation
The author
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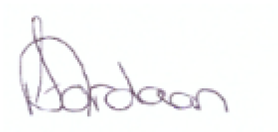
Statement

Hereby the co-authors of these two articles, which form part of this dissertation, Dr M Swanepoel (Supervisor) and Dr T Ellapen (Co-Supervisor), gives permission to the candidate, Miss A Jordaan to include the two articles as part of a Masters' dissertation. The contribution, both advisory and supportive, of the co-authors was within reasonable limits, thereby enabling the candidate to submit her dissertation for examination purposes. This dissertation, therefore, serves as fulfilment of the requirements for the M.A degree in Biokinetics within Physical Activity, Sport and Recreation (PhASRec) in the Faculty of Healthy Sciences at the Potchefstroom Campus of the North-West University.



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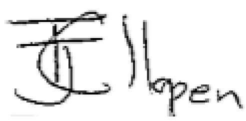

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SUMMARY

Regular adherence to physical activity (PA) amongst individuals with a spinal cord injury (SCI) reduce the risk for developing cardio metabolic disease, and to improve functioning in activities of daily living (ADL) as well as psychological well-being. Specific health benefits of participating in regular PA include: improvement of metabolic profiles *inter alia* a decrease in triglyceride levels (TG), increase in high density lipoprotein cholesterol levels (HDL-C), and decrease in obesity prevalence as well as blood glucose levels. In order to attain these benefits, individuals should perform ≥ 20 minutes of moderate to vigorous intensity aerobic activity, strength training and flexibility exercises at least twice a week. Physical inactivity, which usually occurs among SCI patients, decreases their aerobic capacity, muscle strength, muscle endurance and simultaneously increases the body mass index (BMI) and body fat. These changes adversely affect the health status of SCI patients, which leads to the development of cardio metabolic diseases, type 2 diabetes mellitus and premature death. Regular adherence to PA therefore enhances the quality of life among SCI patients. The prognosis for increased longevity among SCI patients' due to regular PA/exercise has not been documented.

According to literature, a multi-disciplinary approach is needed to increase SCI individuals' adherence to PA therapy. It is also evident from the literature review that in South Africa research in this field of therapeutic science is limited. The scarcity in the literature is alarming as the South African community has a fair number of paraplegics and tetraplegics. It is strongly advised that researchers (especially South Africans) embark on empirical investigations quantifying the optimal program prescription and the health benefits of regular PA therapy for SCI patients, specifically pertaining to their metabolic profiles. This endeavour will contribute valuable information and lessen the present void in this area of research.

The review was limited to English language papers published between (2006 and 2016) on individuals with a spinal cord injury and applying physical activity as treatment modality, focusing on four components of physical fitness (physical capacity, muscular strength, body composition and functional performance). A literature search of peer-reviewed and professional journal publications was conducted in CROSSREF, an academic meta-database including the following search engines: PubMed, Medline, Science Direct, Sabinet and SAePublications.

Keywords:

Spinal cord injury, cardio metabolic disease, physical activity, exercise

OPSOMMING

Gereelde volharding met fisieke aktiwiteit (FA) in spinaalkoordbeseerde (SKB) pasiënte blyk om die risiko vir ontwikkeling van kardio-metaboliese siektes, te laat afneem, en funksionering in aktiwiteite van die daaglikse lewe (ADL) asook psigologiese welstand te verbeter. Spesifieke gesondheidsvoordele wat verkry kan word uit gereelde deelname aan fisieke aktiwiteit sluit in: die verbetering van metaboliese profiele, onder meer ’n afname in trigliseriedvlakke (TG), ’n toename in hoëdigtheid lipoproteïen cholesterolvlakke (HDL-C), en ’n afname in die voorkoms van obesiteit en bloedglukosevlakke. Met die oog op sodanige voordele behoort aërobiese aktiwiteit, kragoefeninge en soepelheid twee maal per week gedoen te word. Individue behoort minstens twee maal per week ≥ 20-minute lank oefeninge van matige tot hoë intensiteit te doen. Fisieke onaktiwiteit, wat gewoonlik onder SKB pasiënte voorkom, laat die aërobiese kapasiteit, spierkrag, en spieruithouvermoë afneem, en gelyktydig hiermee laat dit die liggaamsmassa-indeks (LMI) en liggaamsvet toeneem. Hierdie veranderinge beïnvloed die gesondheidstatus van SKB pasiënte negatief, wat lei tot die ontwikkeling van kardio-metaboliese siektes, tipe 2 diabetes mellitus en tot premature dood. Gereelde volhardende fisieke aktiwiteit verhoog dus die lewensgehalte van SKB pasiënte. Die prognose vir verlengde lewensduur van SKB pasiënte weens gereelde FA/oefening is nog nie gedokumenteer nie.

Volgens die literatuur is ’n multidissiplinêre benadering nodig om SKB individue se volharding met oefen terapie te verseker. Dit is ook opvallend uit die literatuuroorsig dat navorsing in Suid-Afrika op die gebied van terapeutiese wetenskap skaars is. Dit is kommerwekend aangesien daar ’n aansienlike aantal parapleë en tetrapleë hulle in die Suid-Afrikaanse gemeenskap bevind. Daar word sterk aanbeveel dat navorsers (veral Suid-Afrikaners) empiriese navorsing onderneem wat die optimale programvoorskrif en die gesondheidsvoordele van gereelde oefen-terapie vir SKB pasiënte kwantifiseer, spesifiek met verwysing na metaboliese profiele. Hierdie poging sal waardevolle inligting toevoeg en die huidige leemte op hierdie navorsingsgebied grootliks vul.

Die oorsig is beperk tot Engelstalige artikels wat tussen (2006 en 2016) gepubliseer is oor individue met SKB en wat fisieke aktiwiteit as behandelingsmodaliteit benut het, wat op vier komponente van fisiese fiksheid (fisiese kapasiteit, spierkrag, liggaamsamestelling en funksionele prestasie) gefokus is. ’n Literatuursoektog na eweknie hersiende en professionele vaktydskrif-publikasies is in CROSSREF uitgevoer, en akademiese meta-databasis wat die volgende soekenjins insluit: Med, Medline, Science Direct, Sabinet and SAePublications.

Sleutelwoorde:

Spinaalkoord beserings, kardio-metaboliese siekte, fisieke aktiwiteit, oefening

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LIST OF ABBREVIATIONS

A

ACSM	American College of Sports Medicine
ADL	Activities of Daily Living / Aktiwiteit van die daaglikse lewe
AIS	ASIA Impairment Scale
ASIA	American Spinal Injury Association

B

BMI	Body Mass Index
BP	Blood Pressure

C

C	Cervical
CINAHL	Cumulative index to nursing and allied health literature
CSP	Chartered Society of Physiotherapy
CVD	Cardiovascular Disease

F

FA	Fisieke Aktiwiteit
FES	Functional Electrical Stimulated

H

HDL-C	High Density Lipoprotein Cholesterol / Hoëdigtheid lipoproteien
HIV	Human Immunodeficiency Virus
HPCSA	Health Professions Council of South Africa

I

ISNC SCI	International Standards of Neurological Classification of Spinal Cord Injury

L

L	Lumbar
LDL-C	Low Density Lipoprotein Cholesterol
LMI	Liggaams Massa Indeks

LTPA	Leisure Time Physical Activity
N	
n	Sample size
O	
OT	Occupational Therapist
P	
PA	Physical Activity
PICOS	Patient, problem or population; Intervention; comparison, control; outcome and study design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSWB	Psychosocial Wellbeing
Q	
QOL	Quality of Life
R	
RCT	Randomized Control Trial
RM	Repetition maximum
RPE	Rated Perceived Exertion
RSA	Republic of South Africa
S	
SASCA	Southern African Spinal Cord Association
S	Sacral
SCI	Spinal Cord Injury
SKB	Spinaalkoordbesering
SWB	Subjective Wellbeing
T	
T	Thoracic
TB	Tuberculosis
TG	Triglycerides / Trigliseriedes

U

USA	United States of America

V

VO_{2max}	Maximum oxygen uptake
VO_{2peak}	Maximum amount of oxygen utilized

W

WHO	World Health Organization

CHAPTER 1: INTRODUCTION

1.1 Introduction

The benefits of physical activity (PA) for individuals with a spinal cord injury (SCI) are well recognized. Physical activity can limit and prevent numerous changes and challenges that occur after sustaining a SCI including: bladder and bowel disorders, pressure ulcers, neuropathic pain, an increased risk for developing cardiovascular risk factors and pulmonary conditions, metabolic abnormalities, dyslipidaemia, metabolic disorders as well as negative changes in body composition (increase in fat mass and decrease in fat free mass) due to low energy expenditure after SCI. Various studies have shown the benefits associated with participation in PA amongst individual with a SCI to prevent the development of cardio metabolic risk factors, a major health issue among this population.

Participating in physical activity is strongly recommended for individuals with a SCI due to all the health benefits these individuals could experience, for instance, the improvement in ability to complete activities of daily living (ADL), a decrease in insulin resistance, favourable changes in the lipid profiles (increase high-density lipoprotein cholesterol (HDL-C) and decrease low-density lipoprotein cholesterol (LDL-C) and favourable changes in body composition. However, the importance of regular participation in PA or exercise (structured PA) is not always or rarely discussed after sustaining a SCI. Therefore, the reason that come may have the misconception that exercise is dangerous or might aggravate their condition, but it is just the opposite. Taking part in PA is actually beneficial and will not aggravate a SCI.

The purpose of this chapter is to present the problem statement, followed with the research questions, objectives and hypotheses posed for this dissertation. Lastly the structure of the dissertation is provided.

1.2 Problem Statement

SCI's affect numerous individuals worldwide, especially the male population between the ages of 18 and 32 years (Lee *et al*., 2014:110; Thuret *et al*., 2006:628). From a global perspective, it appears that the majority (35% - 53.8%) of SCI's occur due to motor vehicle accidents (Chiu *et al*., 2010:11; Draulans *et al*., 2011:1148) in developed countries. In South Africa motor vehicle accidents attribute to 26% prevalence and causes of SCIs (Joseph *et al*., 2015:693). The second highest contributor of SCIs worldwide is violence, ranging between 22.6% - 37% (Chiu *et al*., 2010:15; Cripps *et al*., 2011:495; Jackson *et al*., 2004:1743).

According to Joseph *et al.* (2015:695) violence induced SCIs is one of the greatest concerns (60%) in South Africa followed by road accidents (26%) induced SCIs (Cripps *et al*., 2011:498). Violence induced SCIs in South Africa is reportedly higher than in Zimbabwe (15%) with the Western Cape Province ratio being 25%, Johannesburg 61% and 62% in South Gauteng 35% - 40% (Draulans *et al*., 2011:1150) of SCIs sustained through violence are due to gunshot wounds (Draulans *et al*., 2011:1150; Joseph *et al*., 2015:695).

Stab wounds contribute to between 22 and 26% of SCIs in the country (Cripps *et al*., 2011:499; Joseph *et al*., 2015:695). South Africa tends to have the lowest proportion of SCIs due to fall incidents when compared to other causes of SCIs (Draulans *et al*., 2011:1149). In South Africa 20% of individuals with tuberculosis (TB) have spinal TB (Garg & Somvanshi., 2011:441). In 2009 approximately 1.2 million new cases of TB were reported among people living with HIV, 90% of these cases of TB were reported in Africa (Garg & Somvanshi., 2011:441). Spinal TB is severe and can be associated with neurologic deficit due to compression of the adjacent neural structures and significant spinal deformity (Rasouli *et al*., 2012:294). The neurological deficit associated with TB spine is divided into two types: (i) paraplegia of early onset usually occurs in the first two years with the active disease, (ii) paraplegia of late onset occurs years after apparent quiescence of the disease (Jain & Kumar., 2013: S624).

The pathophysiology of an acute SCI involves primary and secondary mechanisms of injury (Oyinbo, 2011:282). The primary injury to the cord happen unpredictably where the secondary injury mechanism could be manipulated by proper exogenous interventions (Oyinbo, 2011:282). Primary injury to the spinal cord has four morphological types: impact with transient compression, impact with persistent compression, laceration or distraction (Oyinbo, 2011:282). When the spinal cord is being contused, compressed by a blunt force or lacerated by a sharp penetrating force, neurological damage occurs known as the primary injury (Silva *et al*., 2014:27). The mechanism of a SCIs leads to various physiological events being described as the secondary injury (Silva *et al*., 2014:27). There are about 25 secondary injury mechanisms (Oyinbo, 2011:282). The secondary injury evolves over days or weeks and leads to further neurological damage (Silva *et al*., 2014:27). The final phase after a SCIs is the chronic phase which occurs between days and years after the SCIs was sustained leading to neurological impairments (Cramer *et al*., 2005:2947; Yiu & He, 2009:617). A SCIs cause a deficit in sensory and motor signals across the site the injury occurred as well as the autonomic nervous system (Kirshblum *et al*., 2011:536, Minassian *et al*., 2012:489).

After injury to the spinal cord, lesions to the spinal cord pass through various stages of acute, sub-acute and chronic injury (Kakulas & Kaelan, 2015: S2). The acute stage post SCI is defined as the time period spanning up to one-year post injury. During this phase, most significant and rapid changes occur to the physiological function (Pelletier, 2013:3). The sub-acute phase after a SCI is when rehabilitation occur, after one-year post-injury when the injury is classified as chronic and physiological changes stabilize (Pelletier, 2013:3). Disruption of the spinal cord occurs at the time the injury takes place (Kakulas & Kaelan, 2015: S2), while secondary changes occur later caused by the body's response to the injured tissue (Kakulas & Kaelan, 2015: S2). Examination of the dermatomes and myotomes after injury can help determine which segments of the spinal cord are affected by the SCI (Kirshblum *et al*., 2011:536).

SCI results in either complete or incomplete loss of sensory, somatic and autonomic functions below the level of lesion. A lesion in the cervical spine (C) C1-C8 results in tetraplegia, lesions in the thoracic spine (T), lumbar spine (L) and sacral spine (S) leads to paraplegia (Kirshblum *et al*., 2011:536), most individuals with an SCI have tetraplegia (ACSM., 2017:356). Complete SCI lesion in vertebra L2-S2 lack control of the bladder, bowels and sexual function; the upper extremities and trunk usually have normal function (ACSM, 2017:356). Lesions between T6 & L2 have respiratory and motor control that depends on the functional capacity of the abdominal muscles with less control at T6 and maximal control at L2 (ACSM, 2017:356). Lesions between T1 and T6 might experience autonomic dysreflexia meaning they experience uncoordinated, spinally mediated reflex response, they also experience poor thermoregulation and orthostatic hypotension. In some cases, there is no sympathetic innervation to the heart, heart rate peak is limited to 115 – 130 beats per minute, their breathing capacity is further diminished by paralysis of intercostal muscles; with arms functioning normal (ACSM, 2017:356). Lesions to C5-C8 are tetraplegic. Lesions to C8 have voluntary control of the shoulder, elbow and wrist but limited hand function. Lesions to C5 rely on biceps brachii and shoulder muscles for mobility and self-care. Lesions to C4 requires artificial support for breathing (ACSM, 2017:356). Statistics reflect that 56.7% of new SCI occur in the cervical segment of the spine and 43.3% below the thoracic segment (Noonan *et al.,* 2012:220). SCI are also classified according to severity or completeness of the injury (Pelletier, 2013:3). The American Spinal Injury Association (ASIA) developed the International standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), which is a neurological exam used world-wide to document sensory and motor impairments after a SCI (Kirshblum *et al*., 2011:536). The ASIA assessment is the gold standard for assessing a SCI. The exam is based on neurological responses, touch and pinprick sensations tested in each dermatome, and strength of the muscles that control key motions on both sides of the body. Muscle strength is scored on a scale of 0-5 according to the table on the right, and sensation is graded on a scale of 0-2: 0 is no sensation, 1 is altered or decreased sensation, and 2 is full sensation. Each side of the body is graded independently. When an area is not available, it is recorded as “NT”, “not testable”. The ISNCSCI exam is used for determining the neurological level of injury (the lowest area of full, uninterrupted sensation and function). The completeness or incompleteness of the injury is measured by the ASIA Impairment Scale (AIS) (Kirshblum et al., 2011:536). It uses a scoring system from A to D. A- refers to a complete injury, with no motor or sensory function in the sacral segments of the spine. B-refers to an incomplete injury with sensory function but no motor function below the level of the neurological injury in the sacral segment. C- refers to an incomplete injury where sensory and motor function are preserved, with more than half of the key muscles below the lesion level have a muscle grade below 3. D- refers to incomplete injuries where motor function is preserved below the lesion level but half of the key muscles below the lesion level have a muscle grade of 3 or more. (Kirshblum *et al*., 2011:536)

After a SCIs, many individuals suffer poor health due to physiological and life style changes that occur (Bassett & Ginis, 2011:165). Adults who sustained an SCIs and make use of a wheelchair as their primary: mode of locomotion frequently have increased levels of triglycerides (TG) and glucose intolerance as well as decreased levels of HDL-C (Manns *et al*., 2012:618; Myers *et al.,* 2007:2). Prolonged sitting time has been associated with several metabolic risk factors including increased waist circumference, high body mass index, systolic blood pressure, fasting triglycerides, HDL-C, two-hour post-load plasma glucose and fasting insulin levels (Thorp *et al*., 2010:327).

Individuals with SCIs often experience an increased prevalence of metabolic risk factors and suffer from secondary health conditions such as respiratory disease, cardiovascular disease, osteoporosis and depression (Guilcher *et al*., 2013:894). Secondary health conditions are problematic to all individuals especially for individuals with SCIs since they are not equipped to utilize all muscle groups in order to maximize energy expenditure (Guilcher *et al*., 2013:894). After a SCI, the body experiences physiological changes specifically pertaining to alterations in body composition, primarily due to changes in their metabolism (Myers *et al*., 2007:2; Sheel *et al*., 2008:500). A decline in PA and daily energy expenditure occurs (Myers *et al*., 2007:1; Valent *et al*., 2007:316), resulting in 32-34% of individuals with SCIs to have a prevalence of a secondary risk for the development of metabolic syndrome (central obesity, insulin resistance, hypertension and dyslipidaemia) (Sisto & Evans, 2014:148).

Participation in PA not only helps to maintain metabolic health but also prevents the development of chronic diseases, particularly type 2 diabetes and cardiovascular disease (Manns *et al*., 2012:614). Physical activity is defined as any bodily movement which is produced by skeletal muscles and leads to increased energy expenditure (Caspersen *et al*., 1985:126). Exercise could be defined as physical activity that is planned, structured and repetitive for purposes of conditioning any body part (Caspersen *et al*., 1985:126). Individuals with SCIs face several challenges and barriers in order to participate in physical activity (Scelza *et al*., 2005:576), thus making this population the most inactive population of society (Kehn & Kroll, 2009:1; Tawashy *et al*., 2009:301). Evidence from cross-sectional as well as longitudinal studies have shown the benefits of regular PA on the prevention of chronic disease that occur after a SCI including improving cardiovascular fitness which is associated with an improved lipid profile, body composition and psychological health (Martin Ginis *et al*., 2012:898; Lannem *et al*., 2009:298; Valent *et al*., 2007:328). Additionally, PA has a positive effect on pain, depression, self-worth and quality of life (Anneken *et al*., 2010:398). Individuals with SCIs participating in regular physical activity or exercise tend to show lower incidence of hypertension, ischemic heart disease, diabetes mellitus, obesity, cancer, osteoporosis and mortality rates (Okuyama & Oka, 2009:69).

According to the American College of Sports Medicine (ACSM), individuals with spinal cord injury should participate in physical activity 3-5 times per week (ACSM, 2017:358). The duration of each session should be between 20 and 60 minutes with an intensity of 40-60% of VO_{2max} (ACSM, 2017:340). Modes of exercise amongst others include swimming, wheelchair sports, circuit resistance training, electrically stimulated cycling and electrically stimulated walking. Gradual increases in the regularity, duration or intensity of the exercise program are important to prevent pain or injury (ACSM, 2017:359). Strength training should be done twice a week, using three sets of 8-12 repetitions per exercise at a moderate to high intensity. Modes of resistance training include free weights, weight machines and elastic tubing or bands (Martin Ginis *et al*., 2011:1093).

PA is a therapeutic modality prescribed as medicine by various health professions for various conditions (Strydom *et al*., 2009:641). One such a profession is Biokinetics. Exercise prescription by biokineticist could be either during the presence of an illness or when the threat of illness presents (Strydom *et al*., 2009:641). Exercise can also be prescribed for health promotion or to improve strong points with no threat to health. According to the Health Professions Council of South Africa (HPCSA), the profession of biokinetics focuses on preventative health care, improving and maintaining physical abilities as well as final phase rehabilitation by prescribing scientifically based exercise programs (Strydom *et al*., 2009:642).

The medical team taking care of individuals with a SCI usually consists of a doctor, nurse, physiotherapist, occupational therapist, social worker and clinical psychologist (Pääbo & Pill, 2012:98). The doctor is responsible for the diagnosis and treatment of the initial injury (Pääbo & Pill, 2012:98). The physiotherapist is responsible for keeping the patient's lungs clear of secretions, physically strengthening the patient and for teaching new ways to become independent despite their disability (Pääbo & Pill, 2012:98). The occupational therapist is responsible for preparing the patient for re-integration into society, occupation and to achieve independence (Pillastrini *et al.*, 2008:78). Physiotherapists attend to phase 1 and 2 physical rehabilitation, but as of phase 3, biokineticist enter the rehabilitation cycle to ensure ergonomic functionality and to decrease the development of secondary health risks (Strydom *et al*., 2009:645).

Considering the paucity of the literature pertaining to the role of physical activity during rehabilitation of SCIs, this dissertation entails a literature review that address the following research questions: firstly, what is the status of exercise therapy among spinal cord injured patients in relation to cardio metabolic risk factors and secondly, what physical activity and exercise treatment modality is used to prevent cardio metabolic risk factors in spinal cord injured patients. Answers to these research questions aid in determining the role of physical activity during the prevention, treatment and management rehabilitation of patients with SCIs in order to prevent secondary health risks. The information obtained through this study contribute to the knowledge and enhancement of PA rehabilitation in patients with spinal cord injuries, with specific reference to the profession of biokinetics.

1.3 Objectives

The objectives of this study were:

- To establish from existing literature what is the status of exercise therapy among spinal cord injured patients in relation to cardio metabolic risk factors.
- To establish from existing literature, what physical activity and exercise treatment modality is used to prevent cardio metabolic risk factors in spinal cord injured patients.

1.4 Hypotheses

This review is based on the following hypotheses:

- Reviewed literature indicated that the status of exercise therapy participation is low and the prevalence of cardio metabolic risk factors high amongst individuals with a SCI.
- Reviewed literature indicated that there's a need for spinal injured patients to follow a structured balance exercise programme including aerobic and muscle endurance to prevent cardio metabolic risk factors.

1.5 Structure of your dissertation

Chapter 1: Introduction.

Chapter 2: Literature review: Physical activity prescription during rehabilitation of spinal cord injury

Chapter 3: Article 1: What is the status of exercise therapy among spinal cord injured patients in relation to cardio metabolic risk factors: A systematic review (2013-2016). *African Journal for Physical Health Education, Recreation and Dance*

Chapter 4: Article 2: Physical activity and exercise as treatment modality to prevent cardio metabolic risk factors in SCI patients. A systematic review (2010-2016). *South African Journal for Research in Sport, Physical Education and Recreation*

Chapter 5: Summary, conclusion, limitations and recommendations.

References

ACSM (American College of Sport Medicine). 2017. ACSM's guidelines for exercise testing and prescription. 10th Edition. Lippincott Williams and Wilkins. Philadelphia, 1-472p.

Anneken, V., Hanssen-Doose, A., Hirschfeld, S., Scheuer, T. & Thietje, R. 2010. Influence of physical exercise on quality of life in individuals with spinal cord injury. *Spinal cord*, 48:393-399.

Bassett, R.L. & Ginis, K.A.M. 2011. Risky business: the effects of an individualized health information intervention on health risk perceptions and leisure time physical activity among people with spinal cord injury. *Disability & health journal*, 4(3):165-176.

Caspersen, C.J., Powell, K.E., Christenson, G.M. 1985. Physical activity, exercise and physical fitness: definition and distinctions for health-related research. *Public health reports*, 100(2):126-131.

Chiu, W., Lin, H., Lam, C., Chu, S., Chiang, Y. & Tsai, S. 2010. Epidemiology of traumatic spinal cord injury: comparisons between developed and developing countries. A*sia-Pacific journal of public health*, 22(1):9-18.

Cramer, S.C., Lastra, L., Lacrouse, M.G. & Cohen, M.J. 2005. Brain motor system function after chronic, complete spinal cord injury. *Brain*, 128:2491-2950.

Cripps, R.A., Lee, B.B., Wing, P., Weerts, E., Mackay, J. & Brown, D. 2011. A global mapping for traumatic spinal cord injury epidemiology: towards a living data repository for injury prevention. *Spinal cord*, 49:493-501.

Draulans, N., Kiekens, C., Roels, E. & Peers, K. 2011. Etiology of spinal cord injuries in Sub-Saharan Africa. *Spinal cord*, 49:1148-1154.

Garg, R.K. & Somvanshi, D.S. 2011. Spinal tuberculosis: A review. *The journal of spinal cord medicine*, 34(5):440-454.

Guilcher, S.J.T., Craven, B.C., Lemieux-Charles, L., Casciaro, T., McColl, A. & Jaglal, S.B. 2013. Secondary health conditions and spinal cord injury: an uphill battle in the journey of care. *Disability & rehabilitation*, 35(11):894-906.

Jackson, A.B., Dijkers, M., Devivo, M.J. & Poczatek., R.B. 2004. A demographic profile of new traumatic spinal cord injuries: change and stability over 30 years. *Archives of physical medicine rehabilitation*, 85:1740-1748.

Jain, A.K. & Kumar, J. 2013. Tuberculosis of spine: neurological deficit. *European spine journal*, 22(4): S624-S633.

Joseph, C., Delcarme, A., Vlok., Wahman, K., Phillips, J. & Wikman, L.N. 2015. Incidence and aetiology of traumatic spinal cord injury in Cape Town, South Africa: a prospective, population-based study. *Spinal cord*, 53:692-696.

Kakulas, B.A. & Kaelan, C. 2015. The neuropathological foundations for the restorative neurology of spinal cord injury. *Clinical neurology and neuro surgery*, 129: S1-S7.

Kehn, M. & Kroll, T. 2009. Staying physically active after spinal cord injury: a qualitative exploration of barriers and facilitators to exercise participation. *Bio Med Central public health*, 9(168):1-11.

Kirshblum, S.C., Burns, S.P., Biering-Sorensen, F., Donovan, W., Graves, D.E., Jha, A., Johansen, M., Jones, L. Krassioukov, A., Mulcahey, M.J., Schmidt-Read, M. & Waring, W. 2011. International standards for neurological classification of spinal cord injury. *The journal of spinal cord medicine*, 34(6):535-546.

Lannem, A.M., Sorensen, M., Froslie, K.F. & Hjeltnes, N. 2009. Incomplete spinal cord injury, exercise and life satisfaction. *Spinal cord*, 47:295-300.

Lee, B.B., Cripps, R.A., Fitzharris, M. & Wing, P.C. 2014. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. *Spinal cord*, 52:110-116.

Manns, P.J., Dunstan, D.W., Owen, N. & Healy, G.N. 2012. Addressing the non-exercise part of the activity continuum: a more realistic and achievable approach to activity programming for adults with mobility disability. *Physical therapy*, 92(4):614-625.

Martin Ginis, K.A, Jörgensen, S. & Stapleton, J. 2012. Exercise and sport for persons with spinal cord injuries. *American academy of physical medicine and rehabilitation*,4:894-900.

Martin Ginis, K.A, Hicks, A.L., Latimer, A.E., Warburton, D.E.R., Bourne, C., Ditor, D.S., Goodwin, D.L., Hayes, K.C., McCartney, N., McIlraith, P., Pomerleau, P., Smith, K., Stone. J.A. & Wolfe, D.L. 2011. The development of evidence-informed physical activity guidelines for adults with spinal cord injury. *Spinal cord*, 49:1088-1096.

Minassian, K., Hofstoetter, U. & Tansey, K. 2012. Neuromodulation of lower limb motor control in restorative neurology. *Clinical neurology and neurosurgery*, 114:489-497.

Myers, J., Lee, M. & Kiratli, J. 2007. Cardiovascular disease in spinal cord injury. *American journal of physical medicine & rehabilitation,* 86(2):1-11.

Noonan, V.K., Fingas, M., Farry, A., Baxter, D., Singh, A., Fehlings, M.G. & Dvorak, M.F. 2012.Incidence and prevalence of spinal cord injury in Canada: a national perspective. *Neuroepidemiology,* 38:219–26.

Okuyama, F. & Oka, K. 2009. Correlates of physical inactivity among individuals with physical disabilities. *International journal of sport and health science,* 7:69-78.

Oyinbo, C.A. 2011. Secondary injury mechanisms in traumatic spinal cord injury: a nugget of this multiply cascade. *Acta neurobiologiae experimentalis,* 71:281-299.

Pääbo, L. & Pill, K. 2012. Disability discourse, physiotherapy and physical activity in the lives of people with traumatic spinal cord injury. *Acta kinesiologiae universitatis tartuensis,* 18:94-101.

Pelletier, C.A. 2013. Incorporating physical activity into the rehabilitation process after spinal cord injury. *Kinesology,* 1- 149.

Pillastrini, P., Mugnai, R., Bonfiglioli, R., Curti, S., Mattioli, S., Maioli, M.G., Bazzocchi, G., Menarini, M., Vannini, R. & Violante, F.S. 2008. Evaluation of an occupational therapy program for patients with spinal cord injury. *Spinal cord*, 46:78-81.

Rasouli, M.R., Mirkoohi, M., Vaccaro, A.R., Yarandi, K.K. & Rahimi-Movaghar, V. 2012. Spinal tuberculosis: diagnosis and management. *Asian spine journal,* 6(4): 294-308

Scelza, W.M., Kalpakjian, C.Z., Zemper, E.D. & Tate, D.G. 2005. Perceived barriers to exercise in people with spinal cord injury. *American journal of physical medicine & rehabilitation*, 84(8):576-583.

Sheel, A.W., Reid, W.D., Townson, A.F., Ayas, N.T. & Konnyu, K.J. 2008. Effects of exercise training and inspiratory muscle training in spinal cord injury: A systematic review. *The journal of spinal cord medicine,* 31(5):500-508.

Silva, N.A., Sousa, N., Reis, R.L. & Salgado, A.J. 2014. From basics to clinical: A comprehensive review on spinal cord injury. *Progress in neurobiology*, 114:25-57.

Sisto, S. & Evans, N. 2014. Activity and fitness in spinal cord injury: review and update. *Current physical medicine and rehabilitation reports*, 2:147-157.

Strydom, G.L., Wilders, C.J., Moss, S.J. & Bruwer, E. 2009. A conceptual framework of biokinetic procedures and referral system: an integrated protocol for the various health paradigms. *African journal for physical health education, recreation and dance*, 15(4):641-649.

Tawashy, A.E., Eng, J.J., Lin, K.H., Tang, P.F. & Hung, C. 2009. Physical activity is related to lower levels of pain, fatigue and depression in individuals with spinal-cord injury: a correlation study. *Spinal cord*, 47:301-306.

Thorp, A.A., Healy, G.N., Owen, N., Salmon, J., Ball, K., Shaw, J.E., Zimmet, P.Z. & Dunstan, D.W. 2010. Deleterious associations of sitting time and television viewing time with cardio-metabolic risk biomarkers: AusDiab 2004-2005. *Diabetes care*, 33(2):327-34.

Thuret, S., Moon, L.D.F. & Gage, F.H. 2006. Therapeutic interventions after spinal cord injury. *Neuroscience*, 7:628-643.

Valent, L., Dallmeijer, A., Houdijk, H., Talsma, E. & Van der Woude, L. 2007. The effects of upper body exercises on physical capacity of people with spinal cord injury: a systematic review. *Clinical rehabilitation*, 21:315-330.

Yiu, G. & He, Z. 2009. Glial inhibition of CNS axon regeneration. *Nature reviews neuroscience*, 7(8):67-627.

CHAPTER 2: PHYSICAL ACTIVITY PRESCRIPTION DURING REHABILITATION OF SPINAL CORD INJURY

2.1 Introduction

Paralysis is the most common consequence after a spinal cord injury (SCI) (Harvey, 2016:4). SCIs can impose sudden paralysis as well as severe medical, psychological and social consequences to the individual (Sand *et al*., 2006:183). Individuals who have sustained an SCI require comprehensive medical care and rehabilitation (Harvey, 2016:4; Pellatt, 2007:165). The management of SCI patients is multifaceted and involves the interaction of numerous healthcare professionals, organisations and government services (Harvey, 2016:4). The primary goal of rehabilitation as follows: "to enable a disabled individual to regain optimal functioning of their sensory, cognitive, physical, psychological and social abilities" Blouin and Echeverri (2011).

A great concern among the SCI population is the fact that they frequently adjust to a physically inactive lifestyle, increasing their risk for the development of lifestyle-related chronic disease such as cardio metabolic disease, dyslipidaemia, hypertension, diabetes mellitus (Gorgey, 2014:158; Pelletier *et al*., 2014:392). Therefore, the participation in regular physical activity as part of health promotion strategies among the SCI population is of the utmost importance (Martin Ginis *et al*., 2011:1088; Hicks *et al*., 2011:1103). Leisure time and overall physical activity participation decrease dramatically post-injury after discharge from rehabilitation (Martin Ginis *et al*., 2010:72; van den Berg-Emons *et al*., 2008:2094). Increased sitting time is a major health risk contributing to premature morbidity, increased health risks for chronic diseases and mortality in the SCI population (Gorgey, 2014:159). The purpose of this review chapter is to investigate the role of different occupations involved with the physical rehabilitation of individuals with SCI in a South African context.

This chapter will state the various health disciplines that are involve in treating individuals with a SCI and the responsibility of each discipline. The following topics will be addressed i) health disciplines responsible to implement physical activity (PA) as therapeutic modality during rehabilitation after a spinal cord injury, ii) the role of occupational therapy during rehabilitation after sustaining a spinal cord injury iii) the role of a physiotherapy during rehabilitation after a spinal cord injury iv) the role of specialized physical activity prescription during rehabilitation and after a spinal cord injury and v) the benefits of regular physical activity among individuals with a spinal cord injury.

2.2 Health disciplines responsible to implement physical activity (PA) as therapeutic modality during rehabilitation after a spinal cord injury

A multi-disciplinary medical team is needed when treating individuals with an acute SCI (Fehlings *et al*., 2011:1329). Treatment from a multidisciplinary team commences as soon as the injury is sustained and continues until the patient is admitted to a care centre and in some cases throughout their lifespan (Fehlings *et al*., 2011:1329). Recovery from an SCI depends on the severity of the injury and the treatment a patient receives through each stage of the treatment spectrum (Fehlings *et al*., 2011:1329). The treatment of SCI spans from pre-hospital immobilization to surgical care up to rehabilitation strategies (Fehlings *et al.*, 2011:1329). A multidisciplinary medical team for SCI usually consists of therapists such as a physical therapist (biokineticist), physiotherapist, occupational therapist, rehabilitation nurse and another medical specialist physician, a dietician and a psychologist. (Godney *et al*., 2011:965). In figure 1 an illustration is provided regarding the specific professions providing treatment as a multi-disciplinary team for patients with an SCI. Physicians or general practitioners (GP's) are recognized as the principal source for referral of patients with SCI to participate in leisure-time physical activity (Pelletier *et al*., 2014:395). Gorgey (2014:161) states that the multi-disciplinary team which engages in caring and rehabilitation of patients with SCI needs to comprehend the various benefits of physical activity as an integral part of the rehabilitation program (Gorgey, 2014:161). Acute medical management of individuals with SCI focuses on decreasing additional neurological impairment to the spinal cord and enhancing recovery (Harvey, 2016:4) and rehabilitation after an SCI commences as soon as the individual is medically stable after sustaining the SCI (Harvey, 2016:4). Individuals with long-term neurological conditions such as SCI may use services from multiple healthcare professionals over a prolonged timespan for managing aspects related to their neurological condition (Mulligan *et al*., 2011:400).

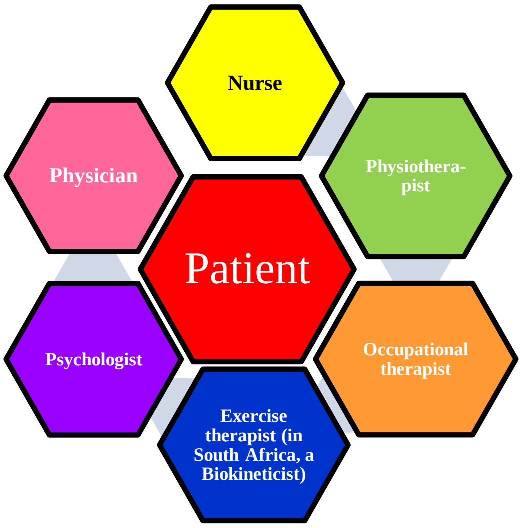

Figure 1 An illustration of the multidisciplinary team treating a patient with an SCI.

2.3 The role of occupational therapy during rehabilitation after a spinal cord injury

Occupational therapy (OT) is a skilled treatment that focuses on assisting patients in achieving independence in all facets of their daily lives (Pillanstrini *et al*., 2008:78). The role of an OT in SCI rehabilitation compromises adaptation to the social and physical living environment (Pillanstrini *et al*., 2008:78). OT's also assist individuals in regaining abilities that are meaningful and important (activities of habitual living) (Pillanstrini *et al*., 2008:78). OT primarily focuses on activities of daily living, home-based activities, sensory, perceptual and cognitive exercises (de Wit *et al*., 2006:1483). According to the Health Professional Council of South Africa (HPCSA, 2016) the scope of practice for occupational therapist in South Africa include: evaluation, improving and maintaining health, development, functional performance or self-assertion of the patient with impairment or at risk of impairment. Prescribing and guiding patients' participation in activities together with application of appropriate techniques to facilitate such participation (HPCSA, 2016).

2.4 The role of a physiotherapy during rehabilitation after a spinal cord injury

Physiotherapists treat an array of diverse complications related to SCI and involve numerous body systems, even though the primary pathology is neurological in nature (Harvey, 2016:4). According to the HPCSA the scope of practice for physiotherapy include orthopaedic, neurology, respiratory disease, cardiovascular disease, obstetrics and gynaecology, intensive care unit and rehabilitation (HPCSA, 1976). They provide exercise therapy that include passive and active movement (HPCSA, 1976). During the phase of acute medical care, physiotherapist's focuses on treating respiratory complications and preventing secondary musculoskeletal problems related to prolonged bed rest (Harvey, 2016:4). The profession also focuses on non-bed lying exercises as well as strengthening exercises and balance (de Wit *et al*., 2006:1483). The physiotherapy rehabilitation phase can vary from a few days to several weeks (Harvey, 2016:4). Physiotherapy is being prescribed as a "supplementary service" to health services and includes the following areas (HPCSA, 1976) orthopaedic; neurological and neurosurgery; respiratory diseases and thoracic-surgery, cardiovascular diseases and surgery , gynaecology, intensive-care unit, rehabilitation of patient to maximal potential in work as well as sport, including permanent disability, sport medicine, paediatrics, geriatrics, treating physical problems of psychiatric patients, relaxation therapy and maintaining recovery of physical fitness.

Physiotherapy helps individuals with SCI to be able to function with their injuries in a day to day situation. It involves exercising for mobilization as well as for stimulation of the nerves and muscles below the level of the injury. Though largely helpful, it only helps the patients with SCI to live with their injury and to prevent further deterioration (Shroff *et al*., 2016:1). Physiotherapy during the rehabilitation of SCI also focuses on goals related to motor tasks such as walking, pushing a wheelchair, transferring and using upper limbs (Harvey, 2016:8). In South Africa the scope of Physiotherapy aims to improve health-related QOL of individuals who sustained a SCI by improving their ability to take part in ADL (Harvey, 2008:124).

Physiotherapy aim to improve participation in PA among individuals with a SCI (Pääbo & Pill, 2012:95). Physiotherapy is shown to improve functioning and prevent secondary complications (Pääbo & Pill, 2012:98).

Treatment should be focused upon that individual and tailored specifically to their condition. A treatment programme is formulated following a thorough physical assessment which might include:

- Stretching activities to maintain muscle and tendon length and reduce or keep muscle spasms/spasticity to a minimum.
- Flexibility and strengthening exercises for the whole body.
- Breathing exercises to maximise lung function and prevent chest infection.
- Balance and posture exercises which can help to reduce pain associated with poor posture and balance impairment and ensure correct transfer techniques (in/out of wheelchair, bed, toilet/bath, car etc.)
- Functional activities to improve fundamental movement patterns such as rolling over and sitting up, and standing where appropriate.
- Walking re-education, if there is sufficient muscle activity and power in the legs.

Evaluations performed by physiotherapists include the determining joint movements, muscle power, muscle strength, muscle tonus, muscle endurance and coordination, rehabilitation, balance and equilibrium reactions; assessing postural abnormalities, functional ability; obtaining a degree of independence. Their scope includes predicting the level of sensory and motor development, length (e.g. bone), the impact of pain on movement, rest and function, assessing gait and other locomotor abnormalities, physical fitness tests and heart (exercise) tolerance test. They also need to determine respiratory excursion and exercise tolerance test and extent; sensory tests, including perception tests, observation; palpation; examining X-rays and X-ray reports; skin temperature and condition; the effects of soft adhesions and contractions in movement, and function tests for nerve conduction and provision; reflection heat test; requirements for use of artificial limbs, prosthesis, tools, appliances, braces, splints, support equipment, corsets, collars etc.; the need for the use of wheelchairs; and any other special tests or methods of evaluation by means of physiotherapy may be necessary for the care and treatment of patients and for the submission of reports to the doctor according to the Chartered Society of Physiotherapy (CSP) (www.csp.org.uk).

Physiotherapists can prescribe the following movement and exercise therapy for individuals with a SCI (HPCSA, 1976):

- Passive movement
- Active movement

Physiotherapist or exercise therapist prescribe final-phase functional movement. Therefore, advance active movements, multi—planar movements, resisted movements, proprioception, graded core stability exercises among paraplegics, hydrotherapy are used as treatment modality when treating individuals with a SCI.

Using various massage techniques, including cross-friction and connective tissue massage; administration of electrotherapy, including (HPCSA, 1976):

- High frequency;
- Low frequency currents;
- Ultrasound;
- Radiation (excluding X-rays and cosmic rays);
- The application of heat and cold; as well as
- The therapeutic use of water (hydrotherapy).

Mechanical aids:

- The production and use of splints and supports.
- The use of props, prosthesis and other therapeutic and assistive devices, including the selection of wheelchairs.

2.5 The role of specialized physical activity prescription during rehabilitation and after a spinal cord injury

During an international conference in Toronto (2010) regarding physical activity (PA) and public health, the focus of the conference centred on the concept "exercise is medicine" (Lobelo *et al*., 2014:43) due to all the benefits of regular PA. Ever since this conference various medical practitioners have already started using exercise in preventing, diagnosing as well as treating clinical conditions and chronic diseases (Lobelo *et al*., 2009:89). It is a well-known fact that individuals with an SCI are less physically active than able-bodied individuals (Motl *et al*., 2005:459) and are therefore more prone to suffer from hypokinetic diseases (Kerstin *et al*., 2006:481; Rauch *et al*., 2013:165). Physical activity is defined as any bodily movement which is produced by skeletal muscles and leads to increased energy expenditure (Caspersen *et al*., 1985:126). Exercise could be defined as physical activity that is planned, structured and repetitive for purposes of conditioning any body part (Caspersen *et al*., 1985:126). The objectives for starting to participate in physical activity as part of rehabilitation after SCI could be multi-focused, such as to evaluate a patient's current physical abilities, to prevent and treat common impairments and to minimize other medical complications (Albert *et al*., 2012:442).

Martin Ginis *et al*. (2010:72) highlights that an immense decrease in physical activity participation occurs after SCI causing these individuals to mostly live a sedentary life. Inactivity is a well-known risk factor for the development of cardiovascular disease and other chronic diseases such as hypertension, diabetes, obesity, bone and joint diseases (such as osteoporosis and osteoarthritis) and depression (Lee *et al*., 2013:219).

Specialized physical activity prescription therefore serves as an important part of the rehabilitation program of SCI patients. A biokineticist is a specialized exercise therapist that operates in professional alliance with health and medicine and is acknowledged and needs to register with the HPCSA. This profession is concerned with preventative health care, maintenance of physical abilities as well as final phase rehabilitation by providing an individualized assessment and a scientifically based physical activity program (HPCSA, 1994). A scientifically based physical-activity program refers to a specific and individual-oriented physical-training programme based on the individuals' physical condition. This program is specifically compiled and supervised (HPCSA, 1994). Final-phase rehabilitation is the phase in the rehabilitation process where physical activity and conditioning constitute the primary therapeutic modality (HPCSA: 1994). A biokineticist aims at improving the physical status and QOL of a patient by providing them with an exercise prescription in dual context of clinical pathology as well as performance enhancement (Strydom *et al*., 2009:642).

Special considerations for individuals with SCI before participating in any PA include: Participants should empty their bowel and bladder before exercising. Avoid any skin pressure sores. There may be a prevalence of decreased cardiovascular performance in individuals with a complete SCI above T6 especially those with complete tetraplegia. During exercise, autonomic dysreflexia result in increased release of catecholamines which increase heart rate, VO_2, blood pressure and exercise capacity. Individuals with a SCI may experience muscular fatigue before achieving substantial central cardiovascular stimulus. In the beginning exercise sessions should consist of short bouts of 5-10 minutes at moderate intensity alternated with active recovery periods of 5 minutes (ACSM, 2017:358). As exercise tolerance improve their training can progress to 10-20 min bouts of vigorous intensity alternated with 5-minute active recovery (ACSM, 2017:358).

Individuals with a SCI have an increased prevalence of abnormalities in carbohydrate and lipid metabolism (Sabour *et al*., 2013:635). Individuals with paraplegia present with increased hypertension, higher BMI and increased levels of LDL-C and TG than individuals with tetraplegia (Sabour *et al*., 2013:635). Due to relative physical inactivity amongst individuals with SCI and body composition changes occur and these individuals are susceptible of increased rates of impaired glucose tolerance, insulin resistance and diabetes mellitus 2 (Bauman & Spungen., 2001:266). Metabolic syndrome is characterized by decrease in HDL-C and increased fasting glucose and TG, increased abdominal obesity and increased BP. Abdominal obesity is major characteristic of metabolic syndrome. Adipokines secreted by adipose tissue contribute to obesity-linked metabolic disease (Maruyama *et al*., 2008:494). The extent of a neurological impairment is an important predictor of post SCI impairment regarding increased levels of serum glucose and plasma insulin during a two-hour oral glucose tolerance test and increased prevalence of impaired glucose tolerance (Maruyama et al., 208:494). Presence of metabolic syndrome are being used to identify the risk for developing CVD (Maruyama *et al*., 2008:494).

CVD is a rising concern among the SCI population, since the risk for developing CVD is 16% higher than for able-bodied individuals' due to their greater inactivity status, increased prevalence of obesity, diabetes, metabolic syndrome and detrimental change in lipid profile (Myers *et al*., 2007:1). Autonomic dysfunction caused by SCI is also associated with numerous conditions that contribute to increased cardiovascular risk, as well as irregularities in blood pressure, heart rate variability, arrhythmias, and a blunted cardiovascular response to exercise that can limit the capacity to perform physical activity (Myers *et al*., 2007:1). Consequently screening, acknowledging and treating CVD ought to be an important component of treating individuals with SCI, and cautious treatment of risk factors can play a significant role in minimizing the occurrence of CVD in these individuals (Myers *et al*., 2007:1) Prevalence for metabolic syndrome is 23% greater after first year post-injury (Lee *et al*., 2004:21). Cross-sectional studies have revealed that men with a SCI represent 8-18% increase in fat mass compared to able bodied men of the same age and height (Buchholz & Bugaresti., 2005:513). Participating in PA has been linked to reduction in total body mass, fat mass, C-reactive protein, insulin and leptin and more favourable profiles associated with individuals who began regular activity closer to sustaining a SCI (Koury *et al*., 2013:119).

2.6 The benefits of regular physical activity among individuals with a spinal cord injury

Physical inactivity among the SCI community not only has a vast negative impact on patients' overall health status, but also adversely affects their metabolic system, for instance a decrease in basal metabolic rate, insulin resistance, impaired glucose tolerance and impaired lipid profile (Giangregorio & McCartney, 2006:489; Gorgey, 2014:158). Physical inactivity also contributes to imbalances of the inflammatory response (Galea, 2011:345). Bed rest after a spinal cord injury causes muscle fibres to rapidly atrophy (Gorgey & Dudley, 2007:304) and causes individuals with an SCI to have an increase in fat mass due to the higher energy expenditure from muscles compared to fat. (Gorgey & Dudley, 2007:305). Six weeks after SCI intramuscular adipose tissue has already increased (Jiang *et al*., 2006:180). Physical inactivity also leads to osteoporosis which increases the risk for fractures among the SCI community (Jiang *et al*., 2006:180). Adverse effects can be decreased partly by increasing physical activity.. Participating in regular physical activity improves fitness and psychological wellbeing among SCI patients (Kehn & Kroll, 2009:168). Participating in regular physical activity after an SCI has several health and wellbeing benefits, such as reducing the risk for any secondary conditions associated with SCI, such as cardio vascular disease, osteoporosis, arthritis, pressure ulcers, urinary tract infections, diabetes, hypertension and dyslipidaemia (Nooijen *et al*., 2012:320; Myers *et al*., 2007:2). Regular PA further enhances functional abilities, increases quality of life and improves social integration (Boslaugh & Andersen., 2006:5; Kehn & Kroll., 2009:11; Latimer & Martin Ginis., 2005:131; Mulligan *et al*., 2011:399; Warburton *et al*., 2006:807).

Disorders in glucose and insulin metabolism may not be a normal characteristic of aging but instead be associated with obesity and physical inactivity (Amati *et al*., 2009:1547). PA is associated with improvements in glucose and insulin metabolism (Boulé *et al*., 2005:108). Daily PA has shown to be a mediator of glycemic control even without diabetes (Mikus *et al*., 2012:225). A single bout of exercise can substantially reduce the prevalence of hyperglycemia for the next 24hours (van Dijk *et al*.,2012:1273). Beneficial effects have been shown with aerobic exercises, resistance exercises or both modes of training (Sigal *et al*., 2007:357). The mechanisms responsible for these exercises induced benefits are complex and include improvements in insulin sensitivity (Winnick *et al*., 2008:777), increase in muscle GLUT 4 number and function (Holten *et al*., 2004:294), improve endothelial function and blood flow (Cohen *et al*., 2008:405). These adaptations are strongly influenced by energy expenditure (Loreto *et al*., 2005:1524).

SCI patients face various barriers to participation in physical activity. These barriers include lack of time to be physically active, lack of internal motivation, limited knowledge of what to do, not knowing where to find appropriate facilities with accessible exercise equipment to use, limited knowledge of fitness professionals that can assist with physical activity (Cowan *et al*., 2013:27). Other barriers include poor knowledge of the benefits of exercising, thinking exercising will cause their condition to aggravate; laziness to participate in physical activity and thinking exercising is too difficult (Kehn & Kroll 2009:167). To facilitate and increase participation in physical activity among the SCI community requires not only knowledge of barrier prevalence but also of how these barriers are related to exercise participation status, for instance whether the patient has previously exercised or is a non-exerciser (Cowan *et al*., 2013:31).

Facilitators to participate in PA include: i) physical improvements in mobility and capability positively influence subjective well-being (SWB) motivating them to continue with PA (Bodwen *et al*., 2008:135), ii) dry and warm weather facilitate participation in PA (Williams *et al*., 2014:416), iii) social support providing emotional support, advice, guidance and physical assistance and transport also contribute as facilitators to PA participation (Price *et al*., 2011:87), iv) developing and embodying a physically active image or identity (Chun & Lee., 2010:403). Individuals with a SCI should not only focus ADL but leisure time physical activity (LTPA) as well as they think it’s the same thing (Letts *et al*., 2011:134). There’s evidence that healthcare professionals were unaware of suitable LTPA opportunities specifically for individuals with a SCI (Kehn & Kroll., 2009:174).

2.7 Summary

Specialist rehabilitation is a multidisciplinary process involving a variety of professional skills in the interest of supporting individuals with SCI in achieving their full potential to function physically, socially and psychologically (Pellatt, 2007:165). Recreational activities including physical rehabilitation assists in shifting the pattern of physical inactivity to being physically more active (Gorgey, 2014:159). Exercise/physical activity is a cornerstone in the prevention of cardiovascular- and metabolic disease, pain (Gorgey, 2014:159; Warburton *et al.*, 2006:174), obesity, deconditioning and depression in SCI patients (Marge, 2008:68). Physiotherapy, occupational therapy and specialized physical activity prescription contribute to the improvement of physical performance, mobility and self-care in SCI patients (Harvey, 2009:184).

References

ACSM (American College of Sport Medicine). 2017. ACSM's guidelines for exercise testing and prescription. 10th Edition. Lippincott Williams and Wilkins. Philadelphia, 1-472p

Albert, T., Blanquart, F.B., Le Chapelain, L., Fattal, C., Goosens, D., Rome, J., Yelnik, A.P. & Perrouinverbe, B. 2012. Physical and rehabilitation medicine (PRM) care pathways: "Spinal cord injury". *Annals of Physical and Rehabilitation Medicine*, 55:440-450.

Amati, F., Dube, J.J., Cohen, P.M., Stefanovic-Racic, M., Toledo, F.G.S. & Goodpaster, B.H. 2009. Physical inactivity and obesity underlie the insulin resistance of aging. *Diabetes Care,* 32: 1547–1549.

Anon. How PhysioFunction Can Help? (Accessed on 3 October 2017). Available from the World Wide Web: https://www.physiofunction.co.uk/conditions-we-treat/spinal-cord-injury

Bauman, W.A. & Spungen, A.M. 2001. Carbohydrate and lipid metabolism in chronic spinal cord injury. *Journal Spinal Cord Medicine*, 24(4):266-277.

Blouin & Echeverri. (2011) International encyclopaedia of rehabilitation. [Accessed on 30 September 2017]. Available from the World Wide Web: http://cirrie.buffalo.edu/encyclopedia/en/article/304/.

Boslaugh, S.E. & Andresen, E.M. 2006. Correlates of physical activity adults with physical disability. *Preventing Chronic Disease*, 3(3):1-14.

Boulé, N.G., Weisnagel, S.J., Lakka, T.A., Tremblay, A., Bergman, R.N., Rankinen, T., Leon, A.S., Skinner, J.S., Wilmore, J.H., Rao, D.C. & Bouchard, C. 2005. Effects of Exercise Training on Glucose Homeostasis. *Diabetes care*, 28:108-114.

Bowden, M.G., Hannold, E.M., Nair, P.M., Fuller, L.B. &Behrman, A.L. 2008. Beyond gait speed: A case report of a multidimensional approach to locomotor rehabilitation outcomes in incomplete spinal cord injury. *Journal of neurologic physical therapy*, 32(3):129-138.

Buchholz, A.C. & Bugaresti, J.M. 2005. A review of body mass index and waist circumference as markers of obesity and coronary heart disease risk in persons with chronic spinal cord injury. *Spinal cord*, 43:513-518.

Capsersen, C.J., Powell, K.E. & Christenso, G.M. 1985. Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research. *Public health reports*, 100(2):126-131.

Chartered society of physiotherapy. 2002. Rules of professional conduct [online]. [Accessed 19 July 217]. Available from World Wide Web: http://www.csp.org.uk.

Chun, S. & Lee, Y. 2010. The role of leisure in the experience of posttraumatic growth for people with spinal cord injury. *Journal of leisure research*, 42:393-415.

Cohen, N.D., Dunstan, D.W., Robinson, C., Vulikh, E., Zimmet, P.Z. & Shaw, J.E. 2008. Improved endothelial function following a 14-month resistance exercise training program in adults with type 2 diabetes. *Diabetes research and clinical practice*, 79:405-411.

Cowan, R.E., Nash, M.S. & Anderson, K.D. 2013. Exercise participation bariere prevalence and association with exercise participation status in individuals with spinal cord injury. *Spinal Cord*, 51:27-32.

De Wit, L., Putman, K., Lincoln, N., Baert, I., Berman, P., Beyens, H., Bogaerts, K., Brinkmann, N., Connell, L., Dejaeger, E., De Weerdt, W., Jenni, W., Lesaffre, E., Leys, M., Louckx, F., Schuback, B., Schupp, W., Smith, B. & Feys, H. 2006. Stroke rehabilitation in Europe. What do physiotherapists and occupational therapists actually do? *Stroke*, 37:1483-1489.

Fehlings, M.G., Cadotte, D.W. & Fehlings, L.N. 2011. A series of systematic reviews on the treatment of acute spinal cord injury: A foundation for the best medical practice. *Journal of neurotrauma*, 28:1329-1333.

Galea, M.P. 2011. Spinal cord injury and physical activity: preservation of the body. *Spinal cord*, 50:344-351.

Giangregorio, L. & McCartney, N. 2006. Bone loss and Muscle atrophy in spinal cord injury: epidemiology, fracture prediction and rehabilitation strategies. *The journal of spinal cord medicine*, 29(5):489-500.

Gorgey, A.S. & Dudley G.A. 2007. Skeletal muscle atrophy and increased intramuscular fat after incomplete spinal cord injury. *Spinal cord*, 45:304-309.

Gorgey, A.S. 2014. Exercise awareness and barriers after spinal cord injury. *World Journal of Orthopaedics*, 15(3):158-162.

Godney, J., Reinhardt, J.D., Haig, A.J. & Li, J. 2011. Developing post-disaster physical rehabilitation: role of the world health organization liaison sub-committee on rehabilitation disaster relief of the international society of physical and rehabilitation medicine. *Journal of rehabilitation medicine*, 43:965-968.

Harvey, L.A. 2008. Management of spinal cord injury: a meta-synthesis of qualitative findings. *Spinal cord*, 45:124-139.

Harvey, L.A. 2016. Physiotherapy rehabilitation for people with spinal cord injuries. *Journal of Physiotherapy*, 62:4-11.

Health Professions Council of South Africa (HPCSA). 1976. Regulations defining the scope of the profession of physiotherapy. http://www.hpcsa.co.za/Uploads/editor/UserFiles/downloads/rules_reg_constitution/scope_of_profession_of_physiotherapy.pdf. Date of access: 19 Aril 2016.

Health Professionals Council of South Africa. 1994. Regulations defining the scope of the profession of biokinetics. http://www.hpcsa.co.za/Uploads/editor/UserFiles/downloads/rules_reg_constitution/regulalations_defining_the_scope_of_the_profession_of_biokinetics.pdf. Date of access: 1994. Web. 19 Apr. 2016.

Health Professions Council of South Africa (HPCSA). 2016. Regulations defining the scope of the profession of occupational therapy.

http://www.hpcsa.co.za/Uploads/editor/UserFiles/downloads/board_occup/scope_of_profession_occ.pdf Date of access: 19 April 2016.

Hicks, A.L., Martin Ginis, K.A., Pelletier, C.A., Ditor, D., Foulon, B. & Wolfe, D.L. 2011. The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: systematic review. *Spinal Cord*, 49:1103-1127.

Holten, M.K., Zacho, M., Gaster, M., Juel, C., Wojtaszewski, J.F.P. & Dela, F. 2004. Strength training increases insulin-mediated glucose uptake, glut4 content, and insulin signalling in skeletal muscle inpatients with type 2 diabetes. *Diabetes*, 53:294-305.

Jiang, S.D., Dai, L.Y. & Jiang, L.S. 2006. Osteoporosis after spinal cord injury. *Osteoporosis International*, 17:180-192.

Kehn, M. & Kroll, T. 2009. Staying physically active after spinal cord injury: a qualitative exploration of barriers and facilitators to exercise participation. *BioMed central public health*, 9:168-179.

Kerstin, W., Gabriele, B. & Richard, L. 2006. What promotes physical activity after spinal cord injury? An interview study from a patient perspective. *Disability and Rehabilitation*, 28(8):481-488.

Koury, J.C., Passos, M.C.F., Figueiredo, F.A., Chain, A. & Franco, J.G. 2013. Time of physical exercise practice after injury in cervical spinal cord-injured men is related to the increase in insulin sensitivity. *Spinal cord*, 51:116-119.

Latimer, A.E. & Martin Ginis, K.A. 2005. The theory of planned behaviour in prediction of leisure time physical activity among individuals with spinal cord injury. *Rehabilitation Psychology*, 50(4):389-396.

Lee, I., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N. & Katzmarzyk, P.T. 2013. Impact of physical inactivity onn the world's major non-communicable diseases. *Lancet*, 380:219-229.

Lee, M., Myers, J., Hayes, A., Madan, S. & Froelicher, V.F. 2004. C-reactive protein, metabolic syndrome, and insulin resistance in individuals with spinal cord injury. *Journal of spinal cord medicine*, 28(1):20-25.

Letts, L., Martin Ginis, K.A., Faulkner, G., Colquhaun, H., Levac, D. & Gorczynski, P. 2011. Preferred methods and messengers for delivering physical activity information to people with spinal cord injury: a focus group study. *American psychological association*, 56(2):128-137.

Lobelo, F., Duperly, J. & Frank, E. 2009. Physical activity habits of doctors and medical students influence their counselling practices. *British journal of sports medicine*, 43:8992..

Lobelo, F., Steinacker, J.M., Duperly, J. & Hutber, A. 2014. Physical activity promotion in health care settings: the "exercise is medicine" global health initiative perspective. *Schweizerische zeitschrift für sportmedizin und sporttraumatologie*, 62(2):42-45.

Di Loreto, C., Fanelli, C., Lucidi, P., Murdolo, G., De Cicco, A., Parlanti, N., Ranchelli, A., Fatone, C., Taglioni, C., Santeusanio, F. & De Feo, P. 2005. Make your diabetic patients walk. Long-term impact of different amounts of physical activity on type 2 diabetes. *Diabetes Care,* 28:1295–1302.

Marge, M. 2008. Secondary conditions revisited: Examining the expansion of the original concept and definition. *Disability and Health Journal*, 1:67-70.

Martin Ginis, K.A., Jetha, A., Mack D.E. & Hetz, S. 2010. Physical activity and subjective well-being among people with a spinal cord injury. *Spinal cord* 48:65-72.

Martin Ginis, K.A., Hicks, A.L., Latimer, A.E., Warburton, D.E.R., Bourne, C. & Ditor, D.S. 2011. The development of evidence-informed physical activity guidelines for adults with spinal cord injury. *Spinal Cord*, 49: 1088-1096.

Maruyama, Y., Mizuguchi, M., Yaginuma, T., Kusaka, M., Yoshida, H., Yokoyama, K., Kasahara, Y., Hosoya, T. 2008. Serum leptin, abdominal obesity and the metabolic syndrome in individuals with chronic spinal cord injury. *Spinal cord*, 46:494-499.

Mikus, C.R., Oberlin, D.J., Libla, J.L., Taylor, A.M., Booth, F.W. & Thyfault, J.P. 2012. Lowering physical activity impairs glycemic control in healthy volunteers. *Medicine and science in sports and exercise*, 44: 225–231.

Motl, R.W., McAuley, E. & Snook, E.M. 2005. Physical activity and multiple sclerosis: *A meta-analysis. Multiple Sclerosis*, 11:459-463.

Mulligan, H., Fjellman-Wiklund, A., Hale, L., Thomas, D. & Hager-Ross, C. 2011. Promoting physical activity for people with neurological disability: Perspectives and experiences of physiotherapist. *Physiotherapy Theory and Practice*, 27(6):399-410.

Myers, L., Lee, M. & Kiratli, J. 2007. Cardiovascular Disease in Spinal Cord Injury an Overview of Prevalence, Risk, Evaluation, and Management. *American journal of physical medicine rehabilitation*, 86:1-8.

Nooijen, C.J., de Groot, S., Postma, K., Bergen, M.P., Stam, H.J., Bussman, JBJ. & van den Berg-Emins, R.J. 2012. A more active lifestyle in persons with a recent spinal cord injury benefits physical fitness and health. *Spinal cord*, 50:320-323.

Pääbo, L. & Pill, K. 2012. Disability discourse, physiotherapy and physical activity in the lives of people with traumatic spinal cord injury. *Acta Kinesiologiae Universitatis Tartuensis*, 18:94-101.

Pellatt, G.C. 2007. Patients, doctors, and therapists' perceptions of professional roles in spinal cord injury rehabilitation: DO they agree? *Journal of International Care*, 21(2):165-177.

Pelletier, C.A., Latimer-Cheung, A.E., Warburton, D.E. & Hicks, A.L. 2014. Direct referral and physical activity counselling upon discharge from spinal cord injury rehabilitation. *Spinal Cord*, 52:392:395.

Pillanstrini, P., Mugnai, R., Bonfiglioli, R., Curti, S., Mattioli, S., Maioli, M.G., Bazzocchi, G. & Menarini, M. 2008. Evaluation of an occupational therapy program for patients with spinal cord injury. *Spinal Cord*, 46:78-81.2006.

Price, P., Stephenson, S., Krantz, L. & Ward, K. 2011. Beyond My Front Door: The Occupational and Social Participation of Adults with Spinal Cord Injury. *OTJR: Occupation, Participation and Health*, 31(2):81-88.

Rauch, A., Fekre, C., Cieza, A., Geyh, S. & Meyer, T. 2013. Participation in physical activity in persons with spinal cord injury: A comprehensive perspective and insights into gender differences. *Disability and Health Journal*, 6(3):165 -176.

Sabour, H., Javidan, A.N. Ranjbarnovin, N., Vafa, M.R. Khazaeipour, Z., Ghaderi, F., Mehrabani, F.K. & Shidfar, F. 2013. Cardiometabolic risk factors in Iranians with spinal cord injury: Analysis by injury-related variables. *Journal of rehabilitation and research development*, 50(5):635-642.

Sand, A., Karlberg, I. & Kreuter, M. 2006. Spinal cord injured persons' conceptions of hospital care, rehabilitation, and a new life situation. *Scandinavian Journal of Occupational Therapy*, 13:183-192.

Shroff, G., Thakur, D., Dhingra, V., Baroli, D. S., Khatri, D. & Gautam, R.D. 2016. Role of physiotherapy in the mobilization of patients with spinal cord injury undergoing human embryonic stem cells transplantation. *Clinical translational medicine*, 5(41)1-9.

Sigal, R.J., Kenney,G.P., Boulé, N.G., Wells, G.A., Prudhomme, D., Fortier, M., Reid, R.D., Tullocj, H., Coyle, D., Phillips, P., Jennings, A. & Jaffey, J. 2007. Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes: a randomized trial. *Annals of international medicine*, 147: 357–369.

Strydom, G.L., Wilders, C.J., Moss, S.J. & Bruwer, E. 2009. A conceptual framework of Biokinetic procedures and referral system: An integrated protocol for the various health paradigms. *African journal for physical, health education, recreation and dance*, 15(4):641-649.

Van den Berg-Emons, R.J., Bussmann, J.B., Haisma, J.A., Sluis T.A., van der Woude, L.J., Bergen, M.P. & Stam, H.J. 2008. A prospective study on physical activity levels after spinal cord injury during inpatient rehabilitation and the year after discharge. *Archives of physical medicine and rehabilitation*, 89(11):2094-2101.

Van Dijk, J.W., Manders, R.J., Tummers, K., Bonomi, A.G., Stehouwer, C.D.A., Hartgens, F. & van Loon, L.J.C. 2012. Both resistance- and endurance-type exercise reduce the prevalence of hyperglycemia in individuals with impaired glucose tolerance and in insulin-treated type 2 diabetic patients. *Diabetologia*, 55: 1273–1282.

Warburton, D.E.R., Nicol, C.W. & Bredin, S.S.D. 2006. Health benefits of physical activity: the evidence. *Canadian medical association journal*, 174(6):801-809.

Williams, T.L., Smith, B. & Papathomas, A. 2014. The barriers, benefits and facilitators of leisure time physical activity among people with spinal cord injury: a meta-synthesis of qualitative findings. *Health psychology review*, 8(4):404-425.

Winnick, J.J., Sherman, M., Habash, D.L., Stout, M.B., Failla, M.L., Belury, M.A. & Schuster, D.P. 2008. Short-term aerobic exercise training in obese humans with type 2 diabetes mellitus improves whole-body insulin sensitivity through gains in peripheral, not hepatic insulin sensitivity. *Journal of clinal endocrinology metabolism*, 93: 771–778.

CHAPTER 3

WHAT IS THE STATUS OF EXERCISE THERAPY AMONG SPINAL CORD INJURED PATIENTS IN RELATION TO CARDIOMETABOLIC RISK FACTORS? A SYSTEMATIC REVIEW (2013-2016)

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Keywords: Spinal cord injury, cardio metabolic disease, physical activity, exercise

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Abstract:

This review was conducted during the period 2013 – 2016, which provides an overview of the evidence associated with exercise therapy, spinal cord injured patients in relation to cardiometabolic risk factors. Numerous studies exist that investigate the benefits associated with regular adherence of exercise therapy among spinal cord injured patients (n=30). The literature indicates the salutogenic effect of regular exercise therapy among active spinal cord injured patients by improving their metabolic profiles and quality of life. Two important themes emerged: (i) a collaborative effort is needed by the psychologists and functional therapists to encourage regular adherence to exercise therapy among spinal cord patients and (ii) the lack of South African research conducted in the area of therapeutic sciences. It is anticipated that this review will encourage South African researchers to conduct empirical investigation in this area of therapeutic science.

Keywords: spinal cord injury, exercise therapy, cardiometabolic risk factors, metabolic syndrome

Introduction

Classifying a SCI involves the identification of which segment of the spine is damaged and to what extent the sensory and motor function is preserved (Pelletier, 2013). Injury of the cervical vertebrae to the first thoracic vertebrae (C1-T1) precipitates tetraplegia, characterised by sensorimotor loss of arms, trunk and pelvic organs (bladder, bowels and sexual organs) and lower limbs (Durstine, Moore, Painter & Roberts, 2011). Paraplegia is characterized by injury from the second to last thoracic vertebrae (T2-12) that results in sensorimotor loss of the trunk, pelvic organs and lower limbs (Kirshblum *et al.*, 2001). The majority of SCI patients acquire their disability during the age range of 15-34 years (do Espirito Santo, Swarowsky, Recchia, Lopes & Illha, 2015). The primary mechanisms of injury are traumatic, involving motor vehicle accidents, violence and sport, while minor percentage of this special population acquire the disability through infection, tumours and/or surgical complications (Durstine *et al*., 2011; Felton, 2014). Traumatic spinal cord injuries incident rate is 32 cases per million people (Durstine *et al*., 2011). The primary aetiology of childhood spinal cord injuries is spina bifida, with an incidence of 2-8 in every 10 000 births (Oliveira, Jacome & Marques, 2014; Vanderbom, Driver & Neru-Hurwit, 2014). Spina bifida is a consequence of malformation in the caudal neural tube, which results in heterogeneous range of structural defects affecting the spinal cord, cerebrum and brainstem (Oliveira *et al*., 2014).

SCI patients receive inpatient exercise therapy but their outpatient exercise therapy and thereafter self-initiated physical activity declines with time (Nooijen, Stam, Bergen, Bongers-Jassen, Valent, van Langeveld & Twisk, 2016). The poor physical activity status of SCI patients has been positively associated with the incidence of metabolic syndrome, obesity, cardiovascular heart diseases and diabetes mellitus (Martin-Ginis, Jorgensen & Stapleton, 2012; Nooijen *et al*., 2016). Metabolic syndrome is clustering of predisposing risk factors of cardiovascular artery disease such as diabetes mellitus, obesity, hypertriglyceridemia (elevated triglyceride levels > 150mg/dl), hypertension and a reduction in high density lipoprotein cholesterol (< 8.6mmol/dl) (Sisto, Lorenzo, Hutchinson, Wenzel & Krassioukpov, 2012). Wong, van Middendorp, Belci, van Nes, Roels, Smith, Hirani & Forbes (2015) report a 45% incidence of overweight SCI patients, while 29% of them are obese. Increased intra-abdominal fat build-up, indicated by a large waist circumference, have a direct role in the development of the metabolic disease (Han & Lean., 2016).

Ten systematic reviews have been published since 2011 to 2015 on the SCI patients and PA (Gelis, Stefan, Colin, Albert, Gault, Goosens, Perrouin-Verbbe, Fattal, Pelissier & Coudeye, 2011; Phillip, Cote & Warburton, 2011, Martin Ginis *et al*., (2012); Crytzer, Dicianno & Kapoor, 2013; Oliveira *et al*., 2014; Vanderbom *et al*., 2014; do Espirito Santo *et al*., 2015). Gelis *et al*. (2011) reported that only 10 empirical investigations have been conducted among SCI patients. Phillip *et al*. (2011) documented the beneficial impact of regular physical activity of the arterial and subsequently cardiovascular health of SCI patients. Martin-Ginis *et al*. (2012) stated that regular physical activity reduces body mass index (BMI), body fat, diabetes mellitus and cardiovascular risk factors among SCI patients. Oliveira *et al*. (2014) identified limited literature supporting the salutogenic effect of exercise, which enhances the cardiorespiratory function and muscle strength of SCI patients. Do Espirito Santo *et al*. (2015) described the beneficial effects of body weight support treadmill therapy to enhance the cardiorespiratory function and physical activity levels of SCI patients (Do Espirito Santo *et al*., 2015). All these reviews identified two pertinent common factors: (i) regular adherence to exercises improves the quality of life of SCI patients; and (ii) the dearth of empirical literature on the impact exercise therapy as on SCI patients' cardiovascular status.

The inclusion of the 2011 reviews, provide a historical framework of the empirical research conducted prior 2011. This indicates how far SCI research has progressed. The authors of this paper decided not only to review literature between 2013 and 2017 to report on the latest findings but also to include the eight review papers published between 2000 and 2013 to reflect the empirical findings of research conducted over the last 20 years (Crtyzer *et al*. (2013); Da Silva Alves *et al*. (2013); Grogery *et al*., 2014; Lu *et al*. (2014); Nightingale *et al.* (2017); Oliveira *et al*. (2014); Sprigle (2014); Tweedy *et al*. (2016)). Previous literature indicates that the physically inactive lifestyle of wheelchair users decreases their basal metabolic rate, and increases their insulin resistance as well as their glucose sensitivity, thereby precipitating the onset of diabetes mellitus together with various other co-morbidities (Grogery *et al*. (2014); Tweedy *et al*. (2016); Jordaan *et al*. (2017). Kressler *et al.* (2014) and Tanhoffer *et al*. (2014) have strongly recommended that wheelchair users engage in a physically active lifestyle to increase their energy expenditure, thereby decreasing body fat and BMI which will positively influence their cardiometabolic profile. Van Straaten, Cloud & Morrow (2014), Kim *et al*. (2015) and others have reported that regular exercise and physical activity also diminish muscular and neuropathic pain, thereby improving quality of life.

The novelty of this paper is the examination of new outpatient exercise therapy developments, new empirical investigations on exercise therapy among SCI patients in the world post the do Espirito *Santo et al*. (2015) review, and the South African status of research undertaken in this field of exercise rehabilitation.

Methodology

The authors followed the standard practices for systematic reviews (PRISMA) (Liberati *et al.,* 2009). The definitions were guided by the PRIMSA checklist for participants, interventions, comparisons, outcomes and study designs (PICOS).

The participants were SCI patients; the intervention was not necessarily a therapeutic intervention but was interpreted as an exposure, namely the effect of exercise therapy on the well-being of SCI patients. The outcomes of interest were (i) SCI patients, (ii) therapeutic interventions for SCI patients, (iii) the effects of exercise therapy on SCI patients' health, (iv) the effects of exercise therapy on SCI patients' cardio metabolic health, (v) the effects of exercise therapy on SCI metabolic syndrome status, and (vi) the effects of exercise therapy on spinal cord injured patients' metabolic status in South Africa. The exclusion criteria were (i) publications prior to 2013, (ii) psychological therapeutic interventions, (iii) non-English papers, and (vi) not peer-reviewed articles.

The quality of individual papers was analysed adopting the modified Downs and Black Appraisal Scale, which examined the quality of randomised controlled trials and non-randomised papers (Downs & Black, 1999). The reason for adopting the modified Downs and Black checklist because not all the items of the original checklist related to this paper as similarly cited Grober *et al.*, 2007. The modified checklist comprised of 12 questions with a maximum of 12 points. Answers were scored either 0 or 1. The questions used were 1,2,3,6,10,11,12,13,15,18,20 and 27.

Table 1 Review of individual papers as per the Modified Downs and Black checklist (n=16).

Authors	Reporting (n=5)	External validity (n=3)	Internal validity (n=3)	Power (n=1)	Total (n=12)	Type of study/ sample size	Findings
Van der Scheer, *et al*. (2013)	4	3	2	1	10	n=40	Low intensity aerobic wheelchair exercises improve the cardiorespiratory function of SCI patients.
Froehlich-Grobe, *et al*. (2014) (RCT)	5	3	3	1	12	n=59	The SCI patients who received psychological and physical support with exercise therapy had a higher adherence than those who did not have this support.
Kressler *et al*. (2014) (RCT)	4	2	3	1	10	n=11	Regular circuit training improves VO_{2peak}, power output and muscle

							strength of non-paralyzed muscles among SCI patients.
Tanhoffer *et al.* (2014) Australia (RCT)	5	2	2	1	10	n= 13	SCI patients who exercise regularly have a high energy expenditure and lower body fat than sedentary counterparts.
Evans *et al.* (2015) (RCT)	4	2	2	1	9	n=8	Body weight–supported stepping provides a minimal cardiovascular challenge for individuals with paraplegia. Emphasis on low weight support during locomotor training can trigger additional heart rate adaptations.
Kim *et al.* (2015) (RCT)	5	3	2	1	11	n=15	Exercise using an indoor hand-bike improves body composition, fasting insulin and fitness levels among SCI patients

La Fountaine, *et al*. (2015)	2	3	2	1	8	n=83	Prolonged sitting and limited physical negatively affect cholesterol status of SCI patients.
Vosloo *et al.* (2015) (RCT)	4	3	3	2	11	n=66	Walking energy expenditure of abled bodied people is higher than SCI patients. Hip flexion contracture limited SCI patients' ability to walk, which reduce their caloric expenditure.
Chen *et al*. (2016)	5	3	2	1	11	n=138	Elastic band exercises improved activities of daily living and functional fitness of wheel chair bound adults.
Nooijen *et al*. (2016) (RCT)	5	3	2	1	11	n = 45	SCI patients need psychological motivation to adhere to regular physical activity.
De Groot *et al* (2013)	4	2	2	1	9	n =130	Sedentary lifestyle does contribute to al of SCI patients to cardio metabolic risk.

Wong *et al.* (2015)	2	2	3	1	8	n = 23	SCIs need to engage in an obesity prevention intervention programme to improve their cardio metabolic risk profile and quality of life.
Da Silva *Alves et al.* (2013)	3	0	0	1	4	Review	Exercise reduces spinal cord injury inflammation.
Lu *et al.* (2014)	5	0	0	1	6	Review	Successful treatment and rehabilitation of SCI patients should include exercise therapy, electrical stimulation and functional electrical stimulation of the upper limb to improve muscle strength, cardio metabolic risk profile, upper limb function, participation in activities of daily living and quality of life.
Oliveira *et al.* (2014)	5	0	2	1	8	Review	A limited amount of literature exists pertaining to spina bifida and exercise. However, this limited amount of

							literature does indicate that exercise enhances cardiorespiratory function and muscle strength of these patients.
Tweedy *et al.* (2016)	4	0	0	0	4	Review	Exercise interventions improve the cardiorespiratory fitness, and decreases cardio metabolic risk profile, pain and depression of SCI patients

A literature search of peer-reviewed and professional journal publications was conducted in CROSSREF, which is academic meta-database housing the following search engines: PubMed, Medline, Science Direct, Ebscohost, CINAHL, and Google scholar (figure 2).

Key words included: spinal cord injured patients, exercise therapy of spinal cord injured patients, exercise therapy of spinal cord patients' cardio metabolic health.

Results

One thousand and ten English publications were identified. However, after stringent evaluation according to the exclusion criteria, only 20 publications were utilized for this review. Seven randomized controlled trials (RCT), six descriptive and seven systematic reviews were identified during this time period. Figure 1 is a graphical representation of the synthesis of literature. Figure 2 is the graphical representation of countries that conducted exercise therapy investigation of SCI patients during the period 2013-2016. The result of the literature search is synthesized into two tables. Table 2 describes the chronological overview of research papers pertaining to exercise therapy and spinal cord injured patients during the period 2013-2016 (n=11). Table 3 reflects the exercise physiological challenges of SCI patients (n=2). Table 4 reflects literature systematic reviews on individuals with a SCI (n=7).

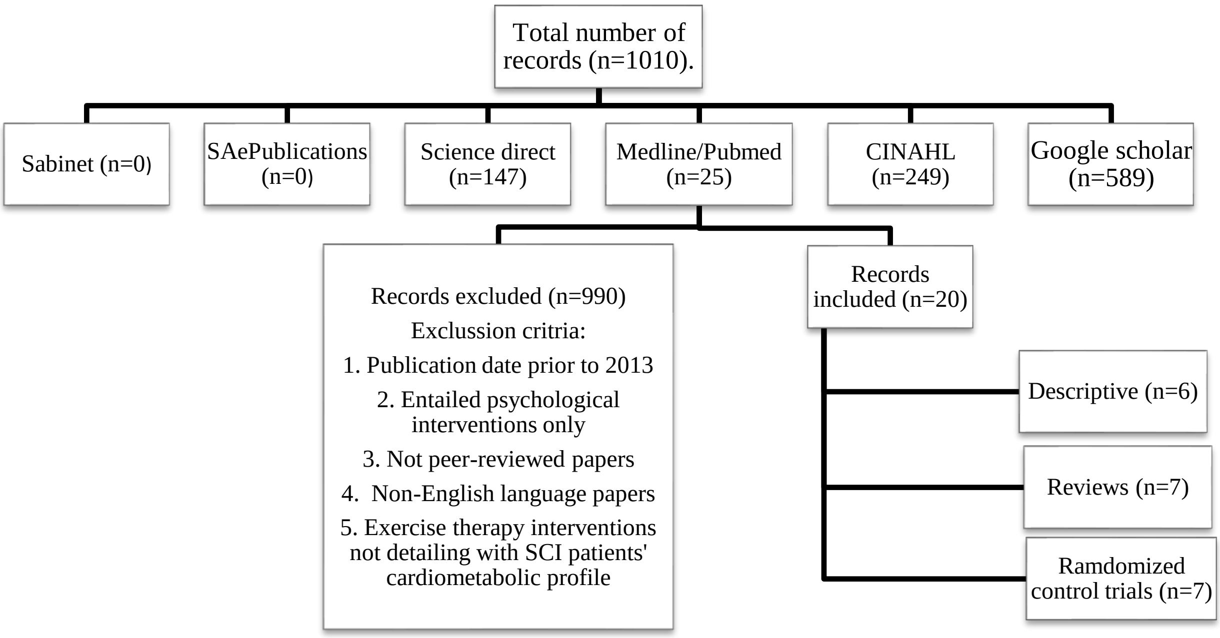

Figure 2 Graphical representation of the synthesis of literature pertaining to SCI and exercise therapy from 2013 - 2016.

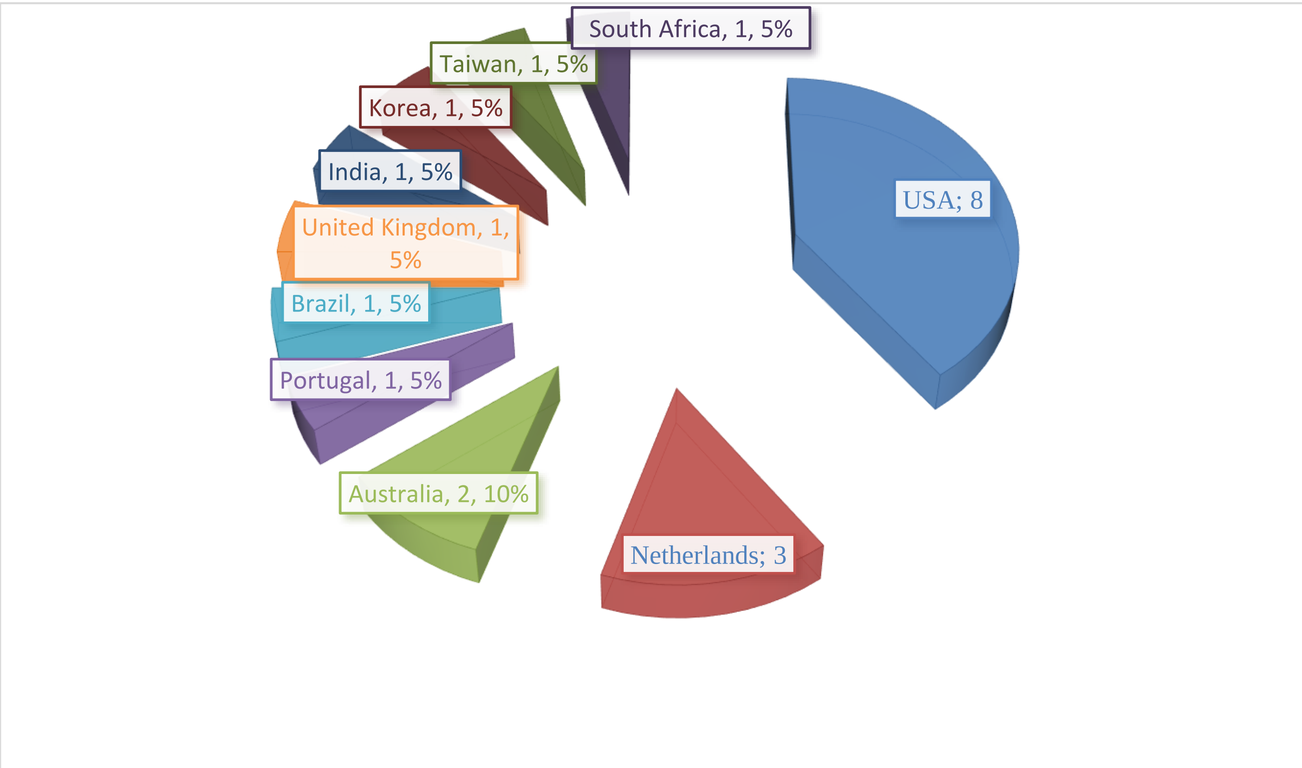

Figure 3 Graphical representation of countries that conducted exercise therapy investigation of SCI patients during the period 2013-2016.

Table 2 Chronological overview of the research papers pertaining to exercise therapy and spinal cord injured patients between 2013-2016 (n=11).

Authors/Country	Sample Characteristics	Findings
Van der Scheer *et al*. (2013) Netherlands	n = 40 Age: 18-65 years	Low intensity aerobic wheelchair exercises improve the cardiorespiratory function of SCI patients.
Froehlich-Grobe *et al*. (2014) USA (RCT)	n = 118 (RCT) Age: 44.5±1.1 years	The SCI patients who received psychological and physical support with exercise therapy had a higher adherence than those who did not have this support.
Kressler *et al*. (2014a) USA (RCT)	n = 5 circuit training n = 6 circuit training and protein supplementation	Regular circuit training improves VO_{2peak}, power output and muscle strength of non-paralyzed muscles among SCI patients.
Kressler *et al*.(2014b) USA	Literature review	Regular exercise reduces the cardio metabolic risk profile of SCI patients.
Tanhoffer *et al.* (2014) Australia (RCT)	Exercise group = 6, Sedentary group = 7 Age: 40 ± 13 years	SCI patients who exercise regularly have a high energy expenditure and lower body fat than sedentary counterparts.
Evans *et al*. (2015) USA (RCT)	Experimental group = 8 Control group = 8	Body weight–supported stepping provides a minimal cardiovascular challenge for individuals with paraplegia. Emphasis on low weight support during locomotor training can trigger additional heart rate adaptations.
Kim *et al*. (2015) Korea (RCT)	Experimental group = 8 Control group = 7	Exercise using an indoor hand-bike improves body composition, fasting insulin and fitness levels among SCI patients

La Fountaine *et al.* (2015) USA	n = 145 Age: 41.3±11.6 years	Prolonged sitting and limited physical negatively affect cholesterol status of SCI patients.
Vosloo *et al*. (2015) RSA (RCT)	n = 45 (SCI patients) n = 21 (able-bodied)	Walking energy expenditure of abled bodied people is higher than SCI patients. Hip flexion contracture limited SCI patients' ability to walk, which reduce their caloric expenditure.
Chen *et al*. (2016) Taiwan	n =138	Elastic band exercises improved activities of daily living and functional fitness of wheel chair bound adults.
Nooijen *et al*. (2016) Netherlands (RCT)	n = 45 Age: 44 ± 15 years	SCI patients need psychological motivation to adhere to regular physical activity.

n = sample, RCT= randomized control trials, SCI = spinal cord injury

Table 3 Exercise physiology challenges of SCI patients (n=2).

Authors/Country	Sample Characteristics	Findings
De Groot *et al*. (2013) Netherlands	n = 130 Age: 4.1 ± 13.8 years	Sedentary lifestyle does contribute to al of SCI patients to cardio metabolic risk.
Wong *et al*. (2015) United Kingdom	n = 645	SCIs need to engage in an obesity prevention intervention programme to improve their cardio metabolic risk profile and quality of life.

n = sample, SCI = spinal cord injury

Table 4 Systematic reviews of SCI patients (2013-2016) (n=5).

Authors/Country	Findings

Da Silva Alves *et al.* (2013) Brazil	Exercise reduces spinal cord injury inflammation.
Lu *et al*. (2014) Australia	Successful treatment and rehabilitation of SCI patients should include exercise therapy, electrical stimulation and functional electrical stimulation of the upper limb in an attempt to improve muscle strength, cardio metabolic risk profile, upper limb function, participation in activities of daily living and quality of life.
Oliveira *et al.* (2014) Portugal	A limited amount of literature exists pertaining to spina bifida and exercise. However, this limited amount of literature does indicate that exercise enhances cardiorespiratory function and muscle strength of these patients.
Evans *et al*. (2015) USA	Regular exercises improve the cardiorespiratory status of SCI patients.
Tweedy *et al.* (2016) Australia	Exercise interventions improve the cardiorespiratory fitness, and decreases cardio metabolic risk profile, pain and depression of SCI patients.

n = sample, SCI = spinal cord injury

Discussion

The discussion will be categorized into (i) the benefits of exercise therapy among spinal cord injured patients, (ii) muscle strength and mass, (iii) challenges concerning the adherence to regular exercise therapy among spinal cord injured patients and (iv) South African research.

Benefits of exercise therapy among spinal cord injured patients

The limited empirical investigations support the salutogenic effect of exercise therapy among SCI patients. The benefits of regular exercise therapy among SCI patients include; (i) enhanced cardiorespiratory function, (ii) decreased BMI, (iii) reduced body fat, and, (iv) improved blood lipid profiles (de Groot *et al.*, 2013, van der Scheer *et al.*, 2013; Tweedy *et al.*, 2016).

Regular exercise increases the energy expenditure, which is derived from adipose tissue eventually reducing body fat and obesity among SCI patients (Martin-Ginis *et al.*, 2012; Tanhoffer *et al.*, 2014). The primary mode of endurance exercising is the application of arm ergometers, swimming, arm cranking and wheelchair propulsion powered by the smaller upper body musculature (ACSM, 2017). The endurance training of the upper body and arms produces peripheral muscular increase in strength and endurance, which translates into 10-20% improvement in peak power output and maximal oxygen consumption (VO_{2max}) (Durstine *et al.*, 2011). The physiological gains are limited by the small muscle mass involved in propagating the endurance activity (Durstine *et al.,* 2011). Upper body power output, VO_{2max} and cardiac output among paraplegics are approximately half of the results of lower limb able-bodied individuals (Durstine *et al.,* 2011), whilst tetraplegics' VO_{2max}, cardiac output and upper body power output is one third to half of that of paraplegics (Durstine *et al.,* 2011). Despite the limited oxidative capacity of the upper-limb muscles, SCI patients who regularly do aerobic exercises can attain a VO_{2max} of 40 ml/kg/min (Tweedy *et al.,* 2016).

In the able-bodied population, regular structured endurance exercise therapy reduces obesity, diabetes mellitus, and triglyceride levels, thereby lowering the predisposing risk of cardiovascular heart diseases (Raymond *et al*., 2010). However, no known empirical literature according to the authors exists validating the impact of regular endurance exercise therapy lowering diabetes mellitus, blood lipid profiles among SCI patients. Nevertheless Fernhall, Hefferman, Jae & Hendrick (2008) and Raymond *et al*., 2014, Harmer, Temesi and van Kempenade (2010) do advocate the intervention of regular exercise therapy to lower the predisposing risk of metabolic and cardiovascular heart diseases. Buchholz, Martin Ginis and Bray (2009) reported that the SCI patients who performed a minimum of 25 minutes of leisure activity daily possess a lower body fat and blood glucose; thereby reducing their metabolic risk profile. These findings provide encouragement for the anecdotal belief that regular exercise therapy can lower SCI patients' metabolic risk profile. It is recommended that future research be undertaken to determine the impact of regular exercise on diabetes mellitus and blood lipid profiles (especially triglycerides and HDL-C).

Muscular strength and muscle mass

SCI patients do experience muscle atrophy and loss of strength due to physical inactivity and the interruption or destruction of the afferent connections of nerve cells (Durstine *et al.,* 2011). Hick, Martin-Ginis, Pelletier, Ditor, Foulon and Wolfe (2011) and do Espirito Santo *et al*. (2015) reported that SCI patients attained muscle strength and endurance and hypertrophy through regular adherence to circuit resistance training, body weight support treadmill training, and arm ergometry. Participants in wheelchair sport such as wheelchair basketball, -rugby and -tennis do exhibit enhanced muscle tone and strength (Tweedy *et al*., 2016), which fuels the optimism that wheelchair sport participation will elicit increased muscle strength and endurance, hypertrophy and cardiovascular endurance which collectively will enhance the physiological well-being and quality of life of the SCI patient.

Challenges concerning adherence to regular exercise therapy among spinal cord injured patients

Many challenges are encountered that prevent SCI patients from adhering to exercise therapy such as financial cost, transport and psychological motivation (Williams *et a*l., 2014). Most SCI patients experience depression following the injury, which withdraws them from physical activity and social contact (Williams *et al.,* 2014). Froehlich-Grobe *et al*. (2014) and Nooijen *et al*. (2016) reported that SCI patients who received psychological support adhered to exercise therapy more regularly than patients who do not have this support. This finding suggests that a collaborative effort should be employed between psychologists and functional therapists to ensure greater adherence of SCI patients to exercise therapy.

South African research contribution: exercise therapy among SCI patients

Literature indicates the United States of America as being the forerunner in research aimed at improving the adherence of SCI patients to exercise therapy and quality of life (Durstine *et al* 2011:). The absence of South African research among SCI patients is conspicuously highlighted, which is alarming due to the large number of South African citizens who have sustained SCI SASCA (2017). Sothmann, Stander, Kruger and Dunn (2014) reported an above average prevalence of SCI patients in South Africa compared to that of the world. Kate (2015) reported that 24.2% of the South African population is living with disability which is higher than the world's 15% average prevalence of disability. Kate (2015) reports that rehabilitation for South African disabled citizens is poorly administrated. It is strongly recommended that South African biokineticists (final-phase rehabilitative exercise therapists) and physiotherapists undertake research in this field of rehabilitative exercise therapy for SCI patients. Furthermore, universities' physiotherapy and biokinetic community service programmes should embark on campaigns to rehabilitate SCI patients; thus ensuring that rehabilitation is reaching the community.

Summary

SCI patients can benefit from regular adherence to exercise therapy, which will improve their metabolic profiles: lower triglyceride levels, increase high density lipoprotein levels, decrease obesity and blood glucose levels. However, the authors have inferred from the literature that a collaborative effort by psychologists and functional therapists is needed to increase SCI patients' adherence to exercise therapy. It is also conspicuous from the literature review that South Africa has not conducted research in this field of therapeutic science. This proves to be alarming since there is numerous number of paraplegics and tetraplegics in the South African community. It is strongly advised that researchers (especially South Africans) embark on empirical investigations quantifying the benefits of regular exercise therapy for SCI patients' metabolic profiles. This endeavour will fill the void in the present body of knowledge.

References

ACSM (American College of Sport Medicine). 2017. ACSM's guidelines for exercise testing and prescription. 10th Edition. Lippincott Williams and Wilkins. Philadelphia, 1-472p.

Buchholz, A.C., Martin-Ginis, K.A., & Bray S.R. (2009). Greater daily leisure time physical activity is associated with lower chronic disease risk in adults with spinal cord injury. *Applied Journal of Physiology Nutrition and Metabolism*, 34, 640-7.

Chen, M., Chen, K., Chang, C., Chang, Y., Cheng, Y. & Huang, H. (2016). Elastic band exercises improved the activities of daily living and the functional fitness of wheel chair bound older adults with cognitive impairment: A cluster randomised control trial. American Journal of Physical Medicine & Rehabilitation, http://www.doi.org/10.1097/PHM.0000000000000518.

Crytzer, T.M., Dicianno, B.E. & Kapoor, R. (2013). Physical activity, exercise and health related measures of fitness in adults with spina bifida: A review of literature. Annals of *Physical and Medical Rehabilitation*, 5(12), 1051-62.

Da Silva Alves, E., De Aquino Lemos, V., Da Silva, F.R., Lira, F.S., Dos Santos, R.V.T., Rosa, J.P.R., Caperuto, E., Tufik, S. & De Mello, M.T. (2013). Low grade inflammation and spinal cord injury: Exercise as Therapy? Mediators of Inflammation, http://www.doi.org/10.1155/2013/971841 .

De Groot, S., Post, W.M., Snoek, G.J. Schuitemaker, M. & Van der Woude, L. (2013). Longitudinal study between lifestyle and coronary heart disease risk factors among individuals with spinal cord injury. *Spinal Cord*, 51, 314-18.

Do Espirito Santo, C.C., Swarowsky, A., Recchia, T.L., Lopes, A.P.S. & Illha, J. (2015). Is body weight support treadmill training effective in increasing muscle tropism after traumatic spinal cord injury? A systematic review. *Spinal Cord*, 53, 176-81.

Downs S.H. & Black N., 1998, 'The feasibility of creating a checklist for the assessment of the methodological quality both of randomized and non-randomized studies of health care interventions', *Journal of Epidemiology in Community Health* 52, 377–384.

Durstine, L.J., Moore, G.E., Painter, P.L. & Roberts, S.O. (2011). ACSM's Exercise Management for Persons with Chronic Diseases and Disabilities (3 ed.). (pp. 298-303) Human Kinetics, USA.

Evans, C.J., Hoffman, S.M., de Leon, R., Domingeuz, J.F., Semerjian, T.Z., Meigar, I.A. & Dy, C.J. (2015). Energy expenditure and heart rate responses to increase loading in individuals with complete motor spinal cord injury performing body weight supported exercises. *Archive of Physical Medicine and Rehabilitation*, 96(8), 1467-73

Fernhall, B., Hefferman, K., Jae, S.Y. & Hendrick, B. (2008). Health implications of physical activity in individuals with spinal cord injury: A literature review. *Journal of Health Human Service and Administration*, 30, 468-502.

Felton, S.D. (2014). Complex injuries of the central nervous system. *Journal of Athletic Training,* 49(3), S17-17.

Froehlich-Grobe, K., Lee, J., Aarson, A., Nary, D.E., Washburn, R.A. & Little, T.D. 2014. Exercise for everyone: a randomised controlled trail of project workout on wheels in promoting exercise among wheelchair users. *Archives of Physical and Medical Rehabilitation*, 95, 20-8.

Gelis, A., Stefan, A., Colin, D., Albert, T., Gault, D., Goosens, D., Perrouin-Verbbe, B., Fattal, C., Pelissier, J. & Coudeye, E. 2011. Therapeutic education in persons with spinal cord injury: A review of literature. *Annals of Physical and Medical Rehabilitation*, 54, 189-210.

Gorber S.C., Tremblay M., Mober D. & Gorber B., 2007, A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A systematic review, *Obesity Reviews* 8, 307–326.

Grogery, A.S., Dolbow, D.R., Dolbow, J.D., Khalil, R.K., Castillo, C. & Gater, D.R. 2014. Effects of spinal cord injury on body composition and metabolic profile – Part 1, *The Journal of Spinal Cord Medicine* 37(6), 693–702.

Han, T.S. & Lean, M.J. 2016. A clinical perspective of obesity, metabolic syndrome and cardiovascular disease. *Journal of the royal society of medicine cardio vascular disease*, 5:1-13.

Hick, A.L., Martin Ginis, K.A., Pelletier, C.A., Ditor, D.S., Foulon, B. & Wolfe, D.L. (2011). The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: A systematic review. *Spinal Cord*, 49, 1103-27.

Jordaan, A., Swanepoel, M. & Ellapen, T.J. 2017. Physical activity and exercise as treatment modality to prevent cardiometabolic risk factors in spinal cord injured patients: A systematic review, *African Journal for Physical Activity and Health Sciences*, in review.

Kate, S. (2015). Disability and Rehabilitation: essential considerations for equitable, accessible and poverty reducing Health Care in South Africa. *South African Health Review*, 89-99.

Kim, D., Lee, H., Lee, B.S., Kim, J. & Jones, J.Y. (2015). Effects of a 6-week indoor hand-bike exercise program on health and fitness levels in people with spinal cord injury: a randomized controlled trial study. *Archive of Physical Medicine and Rehabilitation*, 96(11), 2033-40.

Kirshblum, S.C., Burns, S.P., Biering-Sorensen, F., Donovan, W., Graves, D.E., Jha, A., Johansen, M., Jones, L. Krassioukov, A., Mulcahey, M.J., Schmidt-Read, M. & Waring, W. 2011. International standards for neurological classification of spinal cord injury. *The journal of spinal cord medicine*, 34(6):535-546.

Kressler, J., Burns, P.A. & Betancourt, L. (2014a). Circuit training and protein supplementation in persons with chronic tetraplegia. *Medicine and Science in Sports and Exercise*, 46(7), 1277-84.

Kressler, J., Cowan, R.E. & Bigford (2014b). Reducing cardiometabolic diseases in spinal cord injury. *Physical Medicine Clinical Nutrition*, 25(3), 573-604.

La Fountaine, M.F, Cirnigliaro, C.M., Emmons, R., Kirshblum, C.S., Galea, M., Spungen, A.M. & Bauman, W. (2015). Lipoprotein heterogeneity in persons with spinal cord injury: a model for prolonged and restricted physical activity. *Lipids in Health and Disease*, 14(81), 4-10.

Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P.A., Clarke, M., Devereaux, P.J., Kleijnen, J. &Moher. J. 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *British medical journal*, 339: 1 – 27.

Lu, X., Battistuzzo, C.R., Zoghi, M. & Galea, M.P. (2014). Effects of training on upper limb function after cervical spinal cord injury: A Systematic Review. *Clinical Rehabilitation*, 29(1), 3-13.

Martin Ginis, K.A., Jorgensen, S. & Stapleton, J. (2012). Exercise and sport for persons with spinal cord injuries. *Annals of Physocal and Medical Rehabilitation*, 4(11), 894-900.

Nightingale, T.E., Metcalfe, R.S., Vollaard, N.B.J. & Bilzon, J.L.J., 2017, Exercise guidelines to promote cardiometabolic health in spinal cord injured humans: Time to raise the intensity?, *Archives of Physical Medicine and Rehabilitation* 98(8), 1693–1704.

Nooijen, C.J., Stam, H.J., Bergen, M.P., Bongers-Jassen, M.H., Valent, J., Van Langeveld, S. & Twisk, J. (2016). Behavioural intervention increases physical activity in people with subacute spinal cord injury: a randomised trial. *Journal of Physiotherapy*, 62, 35-41.

Oliveira, A., Jacome, C. & Marques, A. (2014). Physical fitness and exercise training on individuals with spina bifida: a systematic review. *Research in Development Disabilities*, 35, 1119-36.

Pelletier, C.A. 2013. Incorporating physical activity into the rehabilitation process after spinal cord injury. *Kinesology*, 1- 149

Phillip, A.A., Cote, T.A. & Warburton, D.E.R. (2011). A systematic review of exercise as a therapeutic intervention to improve the arterial function in persons living with spinal cord injury. *Spinal Cord*, 49, 702-14.

Raymond, J., Harmer, A.R., Temesi, J. & Van Kempenade, C. (2010). Glucose tolerance and physical activity levels in people with spinal cord injury. *Spinal Cord*, 48, 591-7.

Sisto, S.A., Lorenz, D.J., Hutchinson, K., Wenzel, L. & Krassioukov, A. (2012). Cardiovascular status of individuals with incomplete spinal injury from 7 neuro recovery network rehabilitation centres. *Archives of Physical and Medical Rehabilitation*, 93, 1578-87.

Sothmann, J, Stander, J., Kruger, N. & Dunn, R. (2014). Epidemiology of acute spinal cord injuries in the Groote Schuur Hospital Acute Spinal Cord Injury Unit (GSH ASCI), Cape Town, South Africa over the last 11 years. *South African Medical Journal*, 105(10), 835-9.

Tanhoffer, R.A., Tanhoffer, P.I.A., Raymond, J., Hills, P.A. & Davis, G.M. (2014). Exercise, energy expenditure and body composition in people with spinal cord injury. *Journal of Physical Activity and Health*, 11, 1393-1400.

Tweedy, S.M., Beckmann, E.M., Geraghty, T.J., Theisen, D., Perret, C., Harvey, L.A. & Van Landewijck, Y.C. 2016. Exercise and sport science Australia (ESSA) position statement on exercise and spinal cord injury. *Journal of science and medicine in sport*, 20,108-115.

Vanderbom, K.A., Driver, S. & Nery-Hurwit, M. 2014. A systematic framework to classify physical activity research for individuals with spina bifida. *Disability and health journal*, 7:36-41.

Van der Scheer, J.W., De Groot, S., Posetma, K., Veerger, D.H.E. & Van der Woude, L.H.V. (2013). Design of a randomized-controlled trial on low-intensity aerobic wheelchair exercise for inactive persons with chronic spinal injury. *Disability and Rehabilitation*, 35(13), 1119-26.

Van Straaten, M.G., Cloud, B.A. & Morrow, M.M. 2014. Effectiveness of home exercise on pain, function and strength on manual wheelchair users with spinal cord injury: A high dose shoulder program with telerehabilitation. *Archives of Physical Medicine and Rehabilitation*, 95(10), 1810–1817.

Vosloo, J., Ntsiea, V. & Becker, P. (2015). The energy expenditure of people with spinal cord injury whilst walking compared to able-bodied population. *South African Journal of Physiotherapy*, 72(1), a255.

Williams, T.L., Smith, B. & Papathomas, A. 2017. The barriers, benefits and facilitators of leisure time physical activity among people with spinal cord injury: a meta-synthesis of qualitative findings. *Health psychology review*, 8(4):404-425.

Wong, S., Van Middendorp, J., Belci, M., Van Nes, I., Roels, E., Smith, E., Hirani, S.P. & Forbes, A. (2015). Knowledge, attitudes and practise of medical staff towards obesity management in patients with spinal cord injuries: An International survey for four western European countries. *Spinal Cord*, 53, 24-31.

CHAPTER 4

PHYSICAL ACTIVITY AND EXERCISE AS TREATMENT MODALITY TO PREVENT CARDIOMETABOLIC RISK FACTORS IN SPINAL CORD INJURED (SCI) PATIENTS – A SYSTEMATIC REVIEW (2010-2016)

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Abstract

This review was conducted during the period 2010-2016, providing an overview of the evidence associated with exercise prescription to prevent the development of, or increase in cardio metabolic risk factors among individuals with spinal cord injuries (SCI). Various studies investigated exercise prescription for individuals with spinal cord injuries and found that physical activity prevent the onset cardio metabolic risk factors. Furthermore, two important themes emerged: (i) a multi-disciplinary team approach is needed to ensure individuals with a SCI participate in physical activity, and (ii) there exist a gap in research with regards to the SCI population and exercise prescription to prevent or manage cardio metabolic risk factors in a South African context.

Key words: cardiometabolic risk factors, spinal cord injury, exercise, physical activity.

Introduction

The level of disability associated with a spinal cord injury (SCI) is unique to each injury, depending on the level and integrity of damage to the spinal cord (Martin Ginis *et al*., 2011). Physical deconditioning often occurs after an SCI and frequently leads to increased risk for chronic secondary-health complications (Martin Ginis *et al*., 2011). It is suggested that the early and excessive morbidity and mortality among individuals with a chronic SCI is caused by physical inactivity-related conditions such as cardiovascular disease, type II diabetes as well as osteoporosis (Garshick *et al*., 2005). Quality of life (QOL) and participation in the community is also negatively impacted by loss in fitness and independence associated with physical inactivity (Ravenek *et al*., 2012). These facts highlight the importance of promoting participation in physical activity (PA) among the SCI community to improve their health status, physical fitness and overall QOL. Promoting PA among the SCI community is difficult due to the absence of information regarding the frequency, intensity, type and time spent in physical activity, which yields fitness benefits for this population. Knowledge gained from this review could aid clinicians and other health practitioners to prescribe and promote physical activity and exercise among SCI patients. These facts highlight the importance of promoting participation in physical activity (PA) among the SCI community to improve their health status, physical fitness and overall QOL (Tremblay *et al*., 2010).
This paper aims at addressing the health benefits and prevention of cardio metabolic disease which individuals with SCIs could receive through participation in regular PA and exercise.

Methodology

The authors followed the standard practices for systematic reviews (PRIMSA) (Liberati *et al.*, 2009). The definitions were guided by the PRIMSA checklist for participants, interventions, comparisons, outcomes and study designs (PICOS). The participants were spinal cord injured patients; the intervention was physical activity and exercise, namely the effect of exercise therapy on the health and fitness of spinal cord injured patients. The outcomes of interest were (i) spinal cord injured patients, (ii) exercise guidelines, (iii) the effects of exercise therapy on spinal cord injured patients' health, (iv) the effects of exercise therapy on spinal cord injured patients' cardio metabolic health, (v) types of exercise prescription, and (vi) the effects of exercise therapy on spinal cord injured patients' metabolic status. The exclusion criteria were (i) publications prior to 2010, (ii) non-English papers, (vi) articles that had not been peer-reviewed, and (vii) exercise and physical activity therapy interventions not detailing with SCI patients.

The quality of individual papers was analysed adopting the modified Downs and Black Appraisal Scale, which examined the quality of randomised controlled trials and non-randomised papers (Downs & Black, 1999). The reason for adopting the modified Downs and Black checklist because not all the items of the original checklist related to this paper as similarly cited Grober *et al*., 2007. The modified checklist comprised of 12 questions with a maximum of 12 points. Answers were scored either 0 or 1. The questions used were 1,2,3,6,10,11,12,13,15,18,20 and 27.

Table 5 Review of individual papers as per the Modified Downs and Black checklist (n=14).

Authors	Reporting (n=5)	External validity (n=3)	Internal validity (n=3)	Power (n=1)	Total (n=12)	Type of study/ sample size	Findings
Tawashy *et al.* (2010)	5	1	2	1	9	Intervention n=1	The patient's tolerance to exercise increased in terms of both exercise duration and intensity with an increase in peak oxygen uptake as well as orthostatic tolerance during the entire program
Gater *et al.*, (2011)	4	1	0	1	6	Review	Functional electrical stimulation (FES) during rehabilitation of patients with SCI improves control over bodily functions
Hicks *et al.*, (2011)	4	1	0	1	6	Review	Exercise is proven to improve physical capacity and muscle strength in a chronic SCI population
Galea (2012)	4	1	0	1	6	Review	Physical rehabilitation post-SCI needs to exceed beyond only focussing on independence; it

							should also emphasize maintaining optimal health and fitness as well as maintenance on the body above or below the level of injury.
Martin Ginis *et al*., (2011)	4	1	0	1	6	Review	Physical activity guidelines need to be adopted by patients with SCI, clinicians, researchers as well as exercise therapists. Future research is encouraged in order to determine the physical activity guidelines that will assist rehabilitation practitioners to prescribe appropriate exercise rehabilitative and preventative programmes.
Martin Ginis *et al*., (2012)	4	1	0	1	6	Review	Promoting and facilitating physical activity during SCI rehabilitation is important in the interest of improving patients' physical well-being and psycho-social well-being

Matos-Souza *et al*., (2012)	5	3	2	1	11	Experimental n=54	Physical inactivity plays a direct role in the development of atherosclerosis among SCI patients
Ravenek *et al*., (2012)	4	1	0	1	6	Review	Assessment of quality of life in relation to participation in physical activity shows that participation in physical activity does affect QOL positively among individuals with spinal cord injury
De Groot *et al*., (2013)	5	3	2	1	11	Experimental n=130	Lipid profiles stabilize years after discharge from inpatient SCI rehabilitation, whereas the Body Mass Index (BMI) increases during physically inactive
Gorgey *et al*., (2013) USA	5	3	2	1	11	Experimental n=5	Exercise and diet strategies that focus on fat loss or muscle hypertrophy may be highly recommended to optimize rehabilitation potential post-SCI

Pelletier *et al*., (2014) Canada	5	3	2	1	11	Experimental n=36	Arm only exercise equipment is seen to be safer than hybrid exercise modes post-SCI. There is a difference between equipment types and physiological response
Zwierzchoeska *et al*., (2015)	5	3	2	1	11	Experimental n=24	Metabolic and somatic profiles play an important role with regard to individuals' potential to play wheelchair rugby.
West *et al*., (2015)	5	3	2	1	11	Experimental n=15	Autonomic integrity of SCI and the consequent ability of the cardiovascular system to respond to exercise appear to be critical determinants of endurance performance in elite athletes with cervical SCI
Tweedy *et al*., (2016)	4	1	0	1	6	Review	SCI and the associated co-morbidities adversely affect health, fitness and functioning through an individual's sedentary behaviour. Exercise intervention positively influences health, fitness and functioning

BMI = body mass index, FES = functional electrical stimulation, n = sample, QOL= quality of life, SCI= spinal cord injury

A literature search of peer-reviewed journal publications was conducted in CROSSREF, an academic meta-database including the following search engines: PubMed, Medline, Science Direct, and CINAHL (figure 4).

Key search words were: spinal cord injury, exercise, physical activity, cardiometabolic risk factors.

Results

One thousand, five hundred and sixty-three English publications were identified. However, after stringent evaluation in accordance with the exclusion criteria, only 14 publications were utilized for this review. Five randomized controlled trials (RCT), 2 cross-sectional studies and seven systematic reviews were identified during this time period. Figure 1 Graphic representation of the synthesis of literature pertaining to physical activity and exercise as treatment modality for SCI patients. Figure 2 is a graphic representation of countries that had conducted exercise therapy investigation concerning SCI patients during the period 2010-2016. The results of the literature search are synthesized into Table 1, describing the chronological overview of research papers pertaining to exercise therapy and spinal cord injured patients during the period 2010-2016 (n=14).

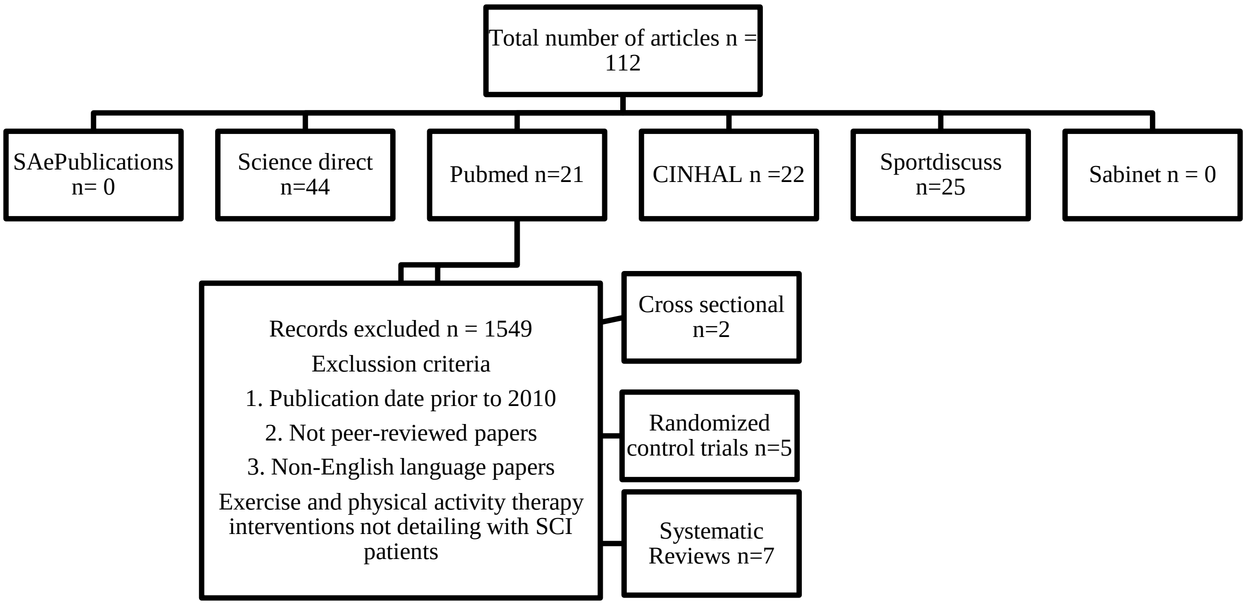

Figure 4 Graphic representation of the synthesis of literature pertaining to physical activity and exercise as treatment modality for SCI patients.

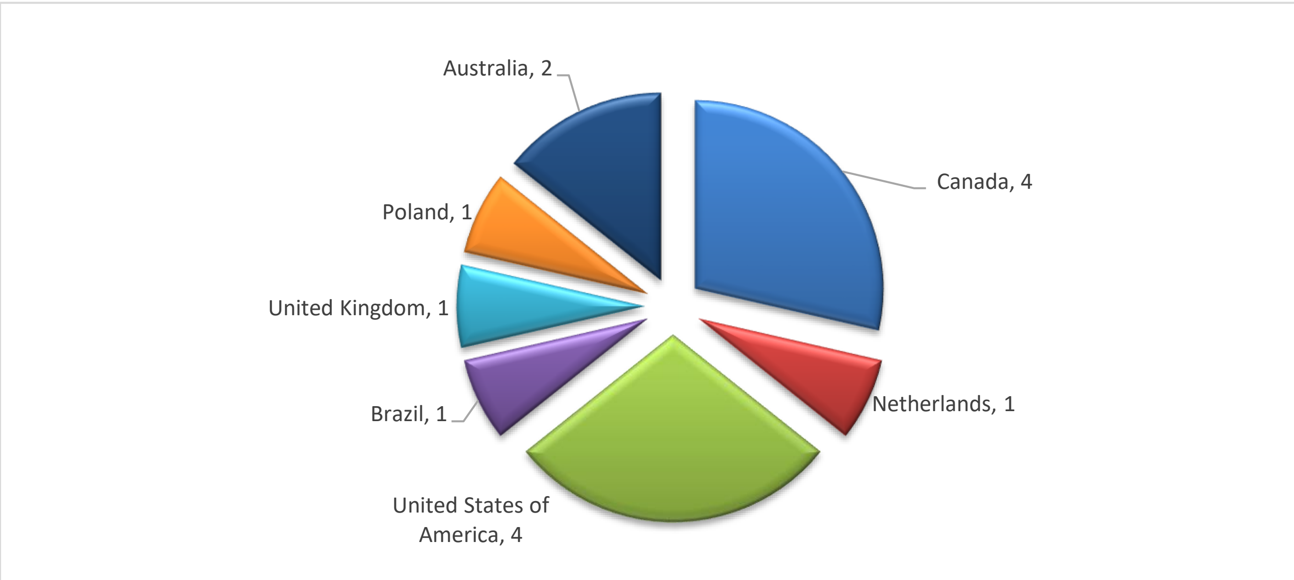

Figure 5 Graphic representation of the countries conducting research concerning exercise therapy on spinal cord injured patients (2010-2016) (n=14).

Table 6 Chronological overview of the research papers pertaining to exercise and physical activity guidelines of spinal cord injured patients between 2010-2016 (n=14).

Authors/Country	Sample Characteristics	Findings
Tawashy *et al*., (2010) USA	n = 1 Age: 22 years	The patient's tolerance to exercise increased in terms of both exercise duration and intensity with an increase in peak oxygen uptake as well as orthostatic tolerance during the entire program.
Gater *et al*., (2011) USA	Review	Functional electrical stimulation (FES) during rehabilitation of patients with SCI improves control over bodily functions.
Hicks *et al*., (2011) Canada	Review	Exercise is proven to improve physical capacity and muscle strength in a chronic SCI population.
Galea (2012) Australia	Review	Physical rehabilitation post-SCI needs to exceed beyond only focussing on independence; it should also emphasize maintaining optimal health and fitness as well as maintenance on the body above or below the level of injury.
Martin Ginis *et al*., (2011) Canada	Review	Physical activity guidelines need to be adopted by patients with SCI, clinicians, researchers as well as exercise therapists. Future research is encouraged in order to determine the physical activity guidelines that will assist rehabilitation practitioners to prescribe appropriate exercise rehabilitative and preventative programmes.

Martin Ginis *et al*., (2012) USA	Review	Promoting and facilitating physical activity during SCI rehabilitation is important in the interest of improving patients' physical well-being and psycho-social well-being.
Matos-Souza *et al*., (2012) Brazil	n = 54	Physical inactivity plays a direct role in the development of atherosclerosis among SCI patients.
Ravenek *et al*., (2012) United Kingdom	Review	Assessment of quality of life in relation to participation in physical activity shows that participation in physical activity does affect QOL positively among individuals with spinal cord injury.
De Groot *et al*., (2013) Netherlands	n = 130	Lipid profiles seem to stabilize in the years after discharge from inpatient SCI rehabilitation, whereas the Body Mass Index (BMI) increases during physical inactivity
Gorgey *et al*., (2013) USA	n = 5	Exercise and diet strategies that focus on fat loss or muscle hypertrophy may be highly recommended to optimize rehabilitation potential post-SCI.
Pelletier *et al*., (2014) Canada	n = 36	Arm only exercise equipment is seen to be safer than hybrid exercise modes post-SCI. There is a difference between equipment types and physiological response.
Zwierzchoeska *et al*., (2015) Poland	n = 24	Metabolic and somatic profiles play an important role with regard to individuals' potential to play wheelchair rugby.
West *et al*., (2015) Canada	n = 15	Autonomic integrity of SCI and the consequent ability of the cardiovascular system to respond to exercise appear to be critical determinants of endurance performance in elite athletes with cervical SCI.

Tweedy *et al*., (2016) Australia	Review	SCI and the associated co-morbidities adversely affect health, fitness and functioning through an individual's sedentary behaviour. Exercise intervention positively influences health, fitness and functioning.

BMI = body mass index, FES = functional electrical stimulation, n = sample, QOL= quality of life, SCI= spinal cord injury

Discussion

The discussion will be categorized into (i) the role of exercise and physical activity in preventing chronic disease, (ii) the role of exercise and physical activity in enhancing physical fitness, (iii) physical capacity, (iv) muscular strength (v) body composition (vi) functional performance (vii) as well as the role of exercise and physical activity in enhancing psychosocial wellbeing, and (viii) special considerations.

The role of exercise and physical activity in preventing cardio metabolic disease

Post-SCI the body undergoes changes in metabolism and body composition that adversely affect the individual's QOL (Bauman & Spungen., 2008). After sustaining an SCI, a drastic decrease in PA occurs, which consequently decreases daily energy expenditure (Fernhall *et al.,* 2008). These changes significantly increase the risk for developing obesity and obesity-related conditions such as diabetes and CVD (Hicks *et al*., 2011). It has been estimated that obesity occurs in 66% of the SCI population (Rajan *et al*., 2008). Individuals with an SCI may have an increased risk for early onset of CVD due to the increased prevalence of hypertension, adverse changes in lipid profiles as well as impaired glucose tolerance and/or type 2 diabetes mellitus (de Groot *et al*., 2013). Studies reported poor lipid and lipoprotein profiles in persons with SCI (Vichiansiri *et al.,* 2012) Research suggests that the low levels of HDL-C concentrations are the consequence of the low levels of PA amongst individuals with a SCI and is mainly due to the result of their wheelchair-dependent life (Tanhoffer *et al*., 2016). Trained SCI individuals had more favourable lipid profiles than untrained SCI individuals, which indicates the important role for PA amongst individuals with a SCI (Tanhoffer *et al*., 2016). Blood lipid levels remains unaltered in the individuals who participate in low intensity exercise, while individuals with a SCI who participate in moderate-intensity exercises exhibited significant increases in HDL-C and decreases in TG, LDL-C and TC/HDL-C ratio (de Groot *et al*., 2013).

The role of exercise and physical activity in enhancing physical fitness

Guidelines for participating in PA for adults with an SCI state that; to achieve fitness benefits, adults should engage in ≥20 minutes of moderate to vigorous intensity aerobic activity at least twice a week (Martin Ginis *et al*., 2011). It is postulated that this prescription is inadequate because SCI patients are generally physically inactive; therefore, the habitual energy expenditure is low. Thus, an exercise prescription of 4 days a week would increase weekly energy expenditure; thereby reducing the risk of obesity, diabetes mellitus and cardiovascular diseases, which concurs adversely affect with exercise rehabilitative prescription of cardiac patients. Our rationale is based on the evidence that SCI patients become cardiac patients. The intensity of their aerobic exercise should range between 11-14 on the RPE Scale and/or 60-75% of heart reserve. Duration should progressively increase from 10-40 minutes per session (Ehrman *et al*., 2013). Strength training should also be included at least twice per week consisting of 3 sets with 8-10 repetitions per exercise for each major muscle group (Martin Ginis *et al*., 2011). Intensity of strength training should start at 40% of the incumbent's 1RM and progress to 70% (Ehrman *et al*., 2013). Flexibility should further be included at least twice a week (Tweedy *et al*., 2016). Flexibility exercises are recommended to preserve upper limb functioning, which may, however, not prevent muscle contracture (Tweedy *et al*., 2016).

Physical capacity

Physical capacity reflects the amount of physical work an individual can perform (Hicks *et al*., 2011). Physical capacity is captured by measuring aerobic capacity and power output (Hicks *et al*., 2011). The greater an individual's aerobic capacity the better their cardiovascular health and their fatigue resistance, which reduces the risk of cardio metabolic diseases (Hicks *et al*., 2011). According to Hicks *et al*., (2011) power output might have a positive impact on an individual's functional independence by enhancing the ability to perform multiple activities of daily living, for example propelling a wheelchair as well as performing transfers. This review further states strong evidence of (i) the effects of FES-assisted exercise, arm ergometry as well as wheelchair exercise on aerobic capacity, and (ii) the effects of FES-assisted exercise and combined aerobic and strength-training on power output (Hicks *et al*., 2011). Regardless of the level of injury, it has repeatedly been demonstrated that individuals with an SCI can achieve and maintain exercise at sufficient intensities to improve cardiorespiratory fitness (Barfield *et al*., 2010). Analysis of initial data suggests that individuals with an SCI tend to participate in sports at a higher intensity and for a longer duration than do individuals participating in exercise (Martin Ginis *et al*., 2010). These results suggest that participating in sport might be an effective type of PA for maximizing cardiorespiratory fitness benefits.

Muscular strength

After an SCI, a loss of muscle mass occurs due to denervation and inactivity leading to a decrease in strength (Martin Ginis *et al*., 2012). According to Martin Ginis *et al*. (2012), the maintenance and/or improvement of muscle strength is important post-SCI. Not only is increased muscle mass associated with enhancement of functional independence, reduction of risk for overused injuries and pain in upper extremities but also the increase of metabolically active tissue (Martin Ginis *et al*., 2012). According to a study done by Hicks *et al*. (2011) strong evidence exist stating that muscular strength can be improved through a variety of exercise modalities including; circuit resistance training, body-weight-supported treadmill training, arm ergometry and FES-assisted exercise.

Body composition

With an increase of fat mass and accompanying decrease in lean muscle mass post-SCI the rapid development of secondary health conditions and cardio metabolic diseases often occurs (Fisher *et al*., 2015; Hicks *et al*., 2011). After an SCI an expedient decrease in bone mineral density due to neural, vascular and hormonal changes increases the risk for osteoporosis and fractures (Jiang *et al*., 2005). Physical activity and exercise mediates positive effects on the detrimental changes that occur in body composition post-SCI (Fisher *et al*., 2015). Resistance training is effective to restore soft tissue lean mass and decrease fat mass (Fisher *et al*., 2015).

Functional Performance

Stationary rowing in a gymnasium or laboratory simulates wheelchair propulsion, improve wheelchair biomechanics (Hicks *et al*., 2011). It is further recommended that kayaking on a river will be an excellent recreational and exercise opportunity for SCI patients (Hicks *et al*., 2011). Improvement of functional performance increase independence and QOL (Hicks *et al*., 2011).

The role of exercise and PA for the enhancement of psycho social wellbeing (PSWB)

PSWB refers to a broad category of phenomena that include mental health, community integration, social participation and overall life satisfaction (Martin Ginis *et al*., 2012; Pelletier *et al*., 2014). Martin Ginis *et al*. (2010) conducted a meta-analysis consisting of 21 studies which examined the association between exercise/sport participation and indices of PSWB and found a significant positive association between PA and PSWB.

Special considerations:

SCI aetiology will have a significant influence (physiologically and biomechanically) on exercise prescription, practitioners should therefore be aware of the fact that an SCI may not be the only impairment individuals' face affecting their ability to exercise (Nott *et al*., 2014; Tweedy *et al*., 2016). Time since injury is associated with the decrease in physical functioning as well as an increase in comorbidities (Charlifue *et al*., 2010). Muscular paralysis reduces the range of exercises possible for individuals with an SCI (Charlifue *et al*., 2010). Therefore, the practitioner, together with the patient, should identify core movements or activities which the client can and cannot do (Conger & Bassett, 2011). Assessment outcomes should include observations regarding patient safety, exercise proficiency and any assistance or adapted equipment that may be required (Conger & Bassett, 2011).

Summary

SCI and its co-morbidities adversely affect one's health, fitness and functioning. These effects are frequently compounded by profoundly sedentary behaviour. Exercise interventions have shown to enhance health, fitness and functioning. Exercise capacity is shown to be reduced in all individuals with SCI, but particularly in individuals with tetraplegia. Strong evidence demonstrates that exercise improves cardio metabolic risk factors, muscular strength, shoulder pain, functional independence and PSWB. Individuals with an SCI should complete ≥ 20 minutes of moderate to vigorous intensity exercise at least twice a week, strength training twice a week including all major muscle groups, and flexibility twice or more often a week. These recommendations may be motivated for sedentary individuals.

References

BARFIELD, J., MALONE, L., ARBO, C. & JUNG, A. 2010. Exercise intensity during wheelchair rugby training. *Journal sports sciences*, 28:389-398.

BAUMANN, W.A. & SPUNGEN, A.M. 2008. Coronary heart disease in individuals with spinal cord injury: Assessment of risk factors. *Spinal cord*, 46:466-476.

CHARLIFUE, S., JHA, A. & LAMMERSTE, D. 2010. Aging with s*pinal cord injury*. *Physical medical rehabilitation clinics of North Americ*a, 21(2):383-402.

CONGER, S.A. & BASSETT D.R. 2011. A compendium of energy costs of physical activities for individuals who use manual wheelchairs. *Adapted Physical Activity Quarterly*, 28(4):310.325.

DE GROOT, S., POST, M.W., SNOEK, G.J., SCHUITEMAKER, M. & VAN DER WOUDE. 2013. Longitudinal association between lifestyle and coronary heart disease risk factors among individuals with spinal cord injury. *Spinal cord*, 51, 314-318.

DOWNS, S.H. & BLACK, N., 1998, 'The feasibility of creating a checklist for the assessment of the methodological quality both of randomized and non-randomized studies of health care interventions', Journal *of Epidemiology in Community Health*, 52, 377-384.

EHRMAN, J.K., GORDON, P.M., VISICH, P.S.& KETEYIAN, S.T. 2009. Clinical exercise physiology, 3rd ed. Champaign, Illnois. Human Kinetics, p.619.

FERNHALL, B., HEFFERNAN, K., JAE, S.Y., HENDRICK, B. 2008. Health implications of physical activity in individuals with spinal cord injury: A literature review. *Journal for health human services,* 30:468-502.

FISHER, J.A., McNELIS, M.A., GORGEY, A.S., DOLBOW, D.R. & GOETZ, L.L. 2015. Does upper extremity training influence body composition after spinal cord injury? *Aging and disease*, 6(4):271-281.

GALEA, M.P. 2012. Spinal cord injury and physical activity: preservation of the body. *Spinal cord*, 50, 344-351.

GARSHICK, E., KELLY, A., COHEN, S.A., GARRISON, A., TUN, C.G., GAGNON, D. & BROWN, R. 2005. A prospective assessment of mortality in chronic spinal cord injury. *Spinal cord,* 43(7):408-416.

GATER, D.R., DOLBOW, D., TSUI, B. & GORGEY, A.S. 2011. Functional electrical stimulation therapies after spinal cord injury. *Neuro Rehabilitation*, 28, 231-248.

GORBER, S.C., TREMBLAY, M., MOBER, D. & GORBER, B., 2007, 'A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A Systematic Review', *Obesity Reviews*, 8, 307-326.

GORGEY, A.S., CHO, G.M., DOLBOW, D.R., & GATER, D.R. 2013. Differences in current amplitude evoking leg extension in individuals with spinal cord injury. *Neuro Rehabilitation*, 33, 161-170.

HICKS, A.L., MARTIN GINIS, K.A., PELLETIER, C.A., DITOR, D.S., FOULON, B. & WOLFE, D.L. 2011. The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: a systematic review. *Spinal cord*, 49, 1103-1127.

JIANG, S.D., DAI, L.Y. & JIANG, L.S. 2005. Osteoporosis after spinal cord injury. *Osteoporosis International*, 17:180-192.

LIBERATI, A., ALTMAN, D.G., TETZLAFF, J., MULROW, C., GØTZSCHE, P.C., IOANNIDIS, J.P.A., CLARKE, M., DEVEREAUX, P.J., KLEIJNEN, J. & MOHER. J. 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *British medical journal*, 339: 1 – 27.

MARTIN GINIS, K.A., JETHA, A., MACK D.E. & HETZ, S. 2010. Physical activity and subjective well-being among people with a spinal cord injury. *Spinal cord* 48:65-72.

MARTIN GINIS, K.A., HICKS, A.L., LATIMER, A.E., WARBURTON, D.E.R., BOURNE, C., DITOR, D.S., GOODWIN, D.L., HAYES, K.C., MCCARTNEY, N., MCLLRAITH, A., POMERLEAU, P., SMITH, K., STONE, J.A. & WOLFE, D.L. 2011. The development of evidence-informed physical activity guidelines for adults with spinal cord injury. *Spinal cord*, 49, 1088-1096.

MARTIN GINIS, K., JORGENSEN, S., STAPLETON, J. 2012. Exercise and Sport for persons with spinal cord injury. *Physical Medication and Rehabilitation*, 4, 894-900.

MATOS-SOUZA, J.R., SILVA, A.A., CAMPOS, L.F., GOULART, D., SCHREIBER, R., DE ROSSI, G., PIO-MAGALHAES, J.A., ETCHEBEHERE, M., GORLA, J.I., CLIQUET, A. & NADRUZ, W. 2012. Physical activity is associated with improved subclinical atherosclerosis in spinal cord injury subject's independent of variation in traditional risk factors. *International journal of cardiology*, 67(2) 592-593.

NOTT, M.T., BAGULEY, I.J. & HERISEANU, R. 2014. Effects of concomitant spinal cord injury and brain injury on medical and functional outcomes and community participation. *Top spinal cord injury rehabilitation*, 20(3):225-235.

PELLETIER, C.A., DITOR, D.S., LATIMER-CHEUNG, A.E., WARBURTON, D.E. & HICKS, A.L. 2014. Exercise equipment preferences among adults with spinal cord injury. *Spinal cord*, 52, 874-879.

RAJAN, S., MCNEELY, M.J., WARMS, C. & GOLDSTEIN, B. 2008. Clinical assessment and management of obesity in individuals with spinal cord injury: A review. *Journal of spinal cord medicine*, 31:361-372.

RAVENEK, K.E., RAVENEK, M.J., HITZIG, S.L. &WOLFE, D.L. 2012. Assessing quality of life in relation to physical activity participation in persons with spinal cord injury: A systematic review. *Disability and Health Journal*, 5, 213-223

TANHOFFER, A.I.P., FERREIRA, M.B., ABE, S., HENNEBERG, R., HAUSER, A.B., NAILWAIKO, K., TANHOFFER, R.A. & FERNANDES, L.C. 2016. Blood Profile and General Health Status in Sedentary and Physically Active Individuals with Spinal Cord Injury. *Journal of Exercise Physiology*, 19(2):76-83.

TAWASHY, A.E., ENG, J.J., KRASSIOUKOV, A.V., MILLER, W.C. & SPROULE, S. 2010. Aerobic exercise during early rehabilitation for cervical spinal cord injury. *Physical Therapy, 90:3*, 427-437.

TREMBLAY, M.S., COLLEY, R.C., SAUNDERS, T.J., HEALY, G.N. & OWEN, N. 2010. Physiological and health implications of a sedentary lifestyle. *Applied Physiology, nutrition and Metabolism*, 36(5):725-740.

TWEEDY, S.M., BECKMAN, E.M., GERAGHTY, T.J., THEISEN, D., PERRET, C., HARVEY, L.A. & VANLANDEWIJCK, Y.C. 2016. Exercise and sports science Australia (ESSA) position statement on exercise and spinal cord injury. *Journal of Science and Medicine in Sport*, 1283, 1-8.

VICHIANSIRI, R., SAENGSUWAN, J., MANIMMANAKORN, N., PATPIYA, S., PREEDA, A., SAMERDUEN, K. & POOSIRIPINYO, E. 2012. The Prevalence of Dyslipidaemia in Patients with Spinal Cord Lesion in Thailand. *Cholesterol*, 2012:1-6.

WEST, C.R., GEE, C.M., VOSS, C., HUBLI, M., CURRIE, K.D., SCHMID, J. & KRASSIOUKOV, A.V. 2015. Cardiovascular control, autonomic function, and elite endurance performance in spinal cord injury. *Scandinavian Journal of Medicine and Science in Sports*, 25, 476-485.

ZWIERZCHOWSKA, A., SADOWSKA-KREPA, E., GLOWACZ, M., MOSTOWIK, A. & MASZCZYK, A. 2015. Comparison of designated coefficients and their predictors in functional evaluation of wheelchair rugby athletes. *Journal of Human Kinetics*, 48, 149-156.

CHAPTER 5: SUMMARY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

Summary

The objectives of this study were, firstly, to establish from existing literature what is the status of exercise therapy among spinal cord injured patients in relation to cardio metabolic risk factors and secondly, to establish from existing literature, what PA and exercise treatment modality is used to prevent cardio metabolic risk factors in SCI patients. Literature have stated that the status of cardio metabolic disease risk factors is directly and positively influenced by regular participation in physical activity amongst individuals with SCI. The more time spent being physically active, the lower the prevalence of cardio metabolic risk factors, the opposite were also documented. In Chapter 1 the problem statement indicates a inadequacy in literature on research done pertaining to the effect of PA and exercise on cardio metabolic health of individuals with a SCI. Limited research could be found within the South African pertaining to this topic therefore, indicating a gap that needs to be explored especially due to the number of South Africans with a SCI. Cardio metabolic health profiles are positively affected by healthy lifestyle habits such as participating in regular PA and exercise. The lack of information such as PA guidelines and detailed information for instance who they could visit for and detailed information for instance who could advise them and recommendations on how to be more physically active. The lack of wheelchair friendly environments causes further barriers to participate in PA. Limited knowledge with regards to the benefits of PA is a major reason among individuals with SCI for not participating in PA as well as the lack of multi-disciplinary team members not providing the necessary referral to exercise specialists in the last phases of treatment.

In Chapter 2, the literature review presents the current evidence of the multidisciplinary team working with SCI individuals abroad and in South Africa. A multi-disciplinary team is needed when working with this population. The team consist of a general practitioner, physician, nurse, dietician, physiotherapist, occupational therapist, exercise therapist (in the South African context a biokineticist) and a psychologist. Treatment commence when injury is sustained and until patient can function on their own after rehabilitation. The primary goal of rehabilitation is to enable a SCI individual to regain functioning of motor sensory, cognitive, psychological, physical and social abilities to take part in activities of daily living and improve their overall health profile. The primary source in referring individuals with a SCI for rehabilitation is physicians and general practitioners. Rehabilitation provided by biokineticist could play an important role in the improvement and maintenance of cardio metabolic health profiles and functional abilities of patients with SCI due to their individualized, scientific evidence based exercise prescription and evaluation of patients’ current health status and possible health risks.

Chapter 3 presented a systematic review which was conducted to investigate the prevalence of cardio metabolic risk factors and the treatment modality for these risk factors. The systematic review focused on the status of exercise therapy among SCI patients in relation to cardio metabolic risk factors. In Chapter 4 another systematic review was conducted which focussed on what modalities of PA and exercise are recommended to prevent cardio metabolic risk factors in SCI patients.

Conclusion

The conclusions drawn from this study are based in the hypotheses stated in Chapter 1. According to literature the United States of America are the forerunner in research aimed at improving the adherence of SCI patients to exercise therapy and improve QOL. The absence of South African research among SCI patients is conspicuously highlighted, which is alarming due to the large number of South African citizens who have sustained SCI. SCI patients can benefit from regular adherence to exercise therapy, which will improve their metabolic profiles: lower lipid profiles (total cholesterol, LDL-C and triglycerides), decrease in obesity prevalence and fasting blood glucose levels.

Secondly, SCI and the associated co-morbidities adversely affect one's health, fitness and functioning. These effects are frequently compounded by profoundly sedentary behaviour. Exercise interventions have shown to enhance health, fitness and functioning. Individuals with an SCI should complete ≥ 20 minutes of moderate to vigorous intensity exercise at least twice a week, strength training twice a week including all major muscle groups, and flexibility twice or more often a week. These recommendations may be aspiring for sedentary individuals.

Therefore, the following:

Hypothesis 1:

Reviewed literature indicated that the status of exercise therapy participation is low and the prevalence of cardio metabolic risk factors high amongst individuals with a SCI, findings from this review confirm this hypothesis and is hereby accepted.

Hypothesis 2:

Reviewed literature indicated that spinal cord injured patients who followed a structured balance exercise programme including aerobic and muscle strengthening exercises endurance showed a lower prevalence in cardio metabolic risk factors and therefore the second hypothesis could also be accepted.

This study indicates a low participation in physical activity from individuals who sustained a SCI. However, the individuals who sustained a SCI and do participate in physical activity have a lower risk in developing cardio metabolic disease risk factors as exercise increase their daily energy expenditure, improve the blood lipid profile, body composition and improves blood pressure. The exercise prescription for health benefits is $\geq$ 20min moderate to vigorous intensity cardiovascular exercise at least twice a week including strength training and flexibility.

Limitations

Limited research is available on benefits of physical activity for patients with spinal cord injury to prevent cardio metabolic disease from developing. Limited research is also available on the role that biokineticist play in rehabilitating patients with a spinal cord injury.

Recommendations

The author recommends an empirical investigation establishing the value of biokinetic rehabilitation pertaining to the quality of life of SCI patients. This research will be novel. The study must record the changes in body composition such as body mass, percent body fat, increased lean muscle mass, maximal oxygen consumption, cardio metabolic profiles, muscle strength and endurance, incidence of musculoskeletal injuries and confidence of patients with a SCI. The dissemination of such findings will be not only the SCI patients but the multi-disciplinary medical team to recognize the significance of biokinetic rehabilitation**.**

Future Research

It is strongly advised that researchers (especially South Africans) embark on empirical investigations quantifying the benefits of regular exercise therapy for SCI patients' cardio metabolic profiles. This endeavour will fill the void in the present body of knowledge.

APPENDICES

APPENDIX A

LANGUAGE EDITING

APPENDIX B

GUIDELINES FOR AUTHORS

AIM

The African Journal for Physical, Health Education, Recreation and Dance (AJPHERD) is a peer-reviewed journal established to:

i) provide a forum for physical educators, health specialists, professionals in human movement studies and dance as well as other sport-related professionals in Africa, the opportunity to report their research findings based on African settings and experiences, and also to exchange ideas among themselves.
ii) afford the professionals and other interested individuals in these disciplines the opportunity to learn more about the practice of the disciplines in different parts of the continent.
iii) create an awareness in the rest of the world about the professional practice in the disciplines in Africa.

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Original manuscript and all correspondence should be addressed to the Editor-In-Chief:

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Manuscripts should be type written in fluent English (using 12-point Times New Roman font and 1½ line-spacing) on one side of whiteA4-sized paper justified fully with 3cm margin on all sides. In preparing manuscripts, MS-Word, Office 2007 for Windows should be used. Length of manuscripts should not normally exceed 12 printed pages (including tables, figures, references, etc.). For articles exceeding 12 typed pages US$ 10.0 is charged per every extra page. Authors will be requested to pay a publication fee to defray the very high cost of publication. The pages of manuscripts must be numbered sequentially beginning with the title page. The presentation format should be consistent with the guidelines in the publication format of the American Psychological Association (APA) (6th edition).

Title page:

The title page of the manuscript should contain the following information:

Concise and informative title.
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A short running title of not more than 6 words.

Abstract

An abstract of 200-250 words is required with up to a maximum of 5 keywords provided below the abstract. Abstract must be typed on a separate page using single line spacing, with the purpose of the study, methods, major results and conclusions concisely presented. Abbreviations should either be defined or excluded.

Text

Text should carry the following designated headings also using single line spacing: Introduction, materials and methods, results, discussion, acknowledgement, references and appendices (if appropriate).

Introduction

The introduction should start on a new page and in addition to comprehensively giving the background of the study it should clearly state the problem and purpose of the study. Authors should cite relevant references to support the basis of the study. A concise but informative and critical literature review is required.

Methodology

This section should provide sufficient and relevant information regarding study participants, ethics/informed consent, instrumentation, research design, validity and reliability estimates, data collection procedures, statistical methods and data analysis techniques used. Qualitative research techniques are also acceptable.

Results

Findings should be presented precisely and clearly. Tables and figures must be presented separately or at the end of the manuscript and their appropriate locations in the text indicated. The results section should not contain materials that are appropriate for presentation under the discussion section. Formulas, units and quantities should be expressed in the *systeme internationale (SI)* units. Colour printing of figures and tables is expensive and could be done upon request at authors' expense.

Discussion

The discussion section should reflect only important aspects of the study and its major conclusions. Information presented in the results section should not be repeated under the discussion. Relevant references should be cited in order to justify the findings of the study. Overall, the discussion should be critical and tactfully written.

References

The American Psychological Association (APA) format should be used for referencing. Only references cited in the text should be alphabetically listed in the reference section at the end of the article. References should not be numbered either in the text or in the reference list.

Authors are advised to consider the following examples in referencing:

Examples of citations in body of the text:-

For one or two authors; Kruger (2003) and Travill and Lloyd (1998). These references should be cited as follows when indicated at the end of a statement: (Kruger, 2003); (Travill & Lloyd, 1998).

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References

In compiling the reference list at the end of the text the following examples for journal references, chapter from a book, book publication and electronic citations should be considered:

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Journal references should include the surname and initials of the author(s), year of publication, title of paper, name of the journal in which the paper has been published, volume and number of journal issue and page numbers.

<u>For one author:</u> McDonald, A.K. (1999). Youth sports in Africa: A review of programmes in selected countries. *International Journal of Youth Sports*, 1(4), 102-117.

For two authors: Johnson, A.G. & O'Kefee, L.M. (2003). Analysis of performance factors in provincial table tennis players. *Journal of Sport Performance*, 2(3), 12-31.
For multiple authors: Kemper, G.A., McPherson, A.B., Toledo, I. & Abdullah, I.I. (1996). Kinematic analysis of forehand smash in badminton. *Science of Racket Sports*, 24(2), 99-112.

Examples of book references:
Book references should specify the surname and initials of the author(s), year of publication of the book, title, edition, page numbers written in brackets, city where book was published and name of publishers. Chapter references should include the name(s) of the editor(s) and other specific information provided in the third example below:

For authored references: Amusa, L.O. & Toriola, A.L. (2003). *Foundations of Sport Science* (2nd ed.) (pp. 39-45). Makhado, South Africa: Leach Printers.
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Electronic sources should be easily accessible. Details of Internet website links should also be provided fully. Consider the following example:

Wilson, G.A. (1997). Does sport sponsorship have a direct effect on product sales? *The Cyber-Journal of Sport Marketing (online)*, October, 1(4), at http://www.cad.gu.au/cjsm/wilson.html. February 1997.

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APPENDIX C

Submission Guidelines for Authors: South African Journal for Research in Sport, Physical Education and Recreation

INFORMATION FOR AUTHORS

The *South African Journal for Research in Sport, Physical Education and Recreation* is published by Stellenbosch University. Contributions from the fields of Sport Science, Physical Education, Recreation/Leisure Studies, Exercise Science and Dance Studies will be considered for publication. The articles submitted will be administered by the appropriate Subject Review Editor and evaluated by two or more referees. The decision as to whether a particular article is to be published or not, rests with the Editorial Board.

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Manuscripts should be typed with **one and a half spacing** in 12-point Times New Roman letter size. The original manuscript can be submitted by e-mail. The length may not exceed 20 pages (tables, figures, references, etc. included). The **page setup** (cm) must be in the following format:

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Example:

CAPE ARGUS (The) (1980). 10 January, p.4.

INTERVIEWS

Example:

POTGIETER, J.R. (2003). Personal interview with the Chairperson of the Department of Sport Science. 31 January. Stellenbosch: Stellenbosch University.

CORRESPONDENCE

Example:

POTGIETER, J.J.J. (2003). Personal correspondence of the Director of the Sport Bureau, 5 February. Stellenbosch: Stellenbosch University.

CONGRESS PROCEEDINGS

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RENSON, R. (Ed.) (1976). *The history, the evolution and diffusion of sport and games in different cultures*. Proceedings of the 4[th] International HISPA Congress, Leuven, Belgium, 1-5 April 1975. Brussels (Belgium): B.L.O.S.O.

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REES, R. (1976). Organisation of sport in nineteenth century Liverpool. In R. Renson (Ed.), *The history, the evolution and diffusion of sport and games in different cultures* (pp.237-247). Proceedings of the 4th International HISPA Congress, Leuven, Belgium, 1-5 April 1975. Brussels (Belgium): B.L.O.S.O.

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