Accepted Manuscript

Title: Exercise and Sports Science Australia (ESSA) Position Statement on Exercise and spinal cord injury

Author: Sean M Tweedy Emma M Beckman Tim Geraghty Daniel Theisen Claudio Perret Lisa A Harvey Yves C Vanlandewijck

PII:	S1440-2440(16)00032-3
DOI:	http://dx.doi.org/doi:10.1016/j.jsams.2016.02.001
Reference:	JSAMS 1283

To appear in: *Journal of Science and Medicine in Sport*

Received date:	30-9-2015
Revised date:	14-1-2016
Accepted date:	5-2-2016

Please cite this article as: Tweedy SM, Beckman EM, Geraghty T, Theisen D, Perret C, Harvey LA, Vanlandewijck YC, Exercise and Sports Science Australia (ESSA) Position Statement on Exercise and spinal cord injury., *Journal of Science and Medicine in Sport* (2016), http://dx.doi.org/10.1016/j.jsams.2016.02.001

Title: Exercise and Sports Science Australia (ESSA) Position Statement on Exercise and spinal cord injury.

Authors: Sean M Tweedy[a], Emma M Beckman[a], Tim Geraghty[b], Daniel Theisen[c], Claudio Perret[d], Lisa A Harvey[e], Yves C Vanlandewijck[f]

[a] The University of Queensland, School of Human Movement Studies, Australia

[b] Queensland Spinal Cord Injuries Service, Princess Alexandra Hospital, Metro South Health, Brisbane, Australia

[c] Sports Medicine Research Laboratory, Public Research Centre for Health, Luxembourg, Grand-Duchy of Luxembourg

[d] Institute of Sports Medicine, Swiss Paraplegic Centre Nottwil, Switzerland

[e] John Walsh Centre for Rehabilitation Research, Sydney Medical School/Northern, University of Sydney, Australia

[f] Katholieke Universiteit Leuven, Faculty of Kinesiology and Rehabilitation Sciences, Belgium

Corresponding Author:

Sean Tweedy, PhD

School of Human Movement and Nutrition Sciences (#26B), Rm 526

The University of Queensland | St Lucia Campus

Brisbane Q 4072 Australia

Ph: +61 7 3365 6638

Fax: +61 7 3365 6877

e-mail: s.tweedy@uq.edu.au

Word Count: 3999

Abstract Word count: 250

Tables: 3

Figures: 0

Exercise and Sports Science Australia (ESSA) Position Statement on Exercise and spinal cord injury.

Abstract

Traumatic spinal cord injury (SCI) may result in tetraplegia (motor, sensory and/or autonomic nervous system impairment of the arms, trunk and legs) or paraplegia (impairment of the trunk and/or legs only). The adverse effects of SCI on health, fitness and functioning are frequently compounded by profoundly sedentary behaviour. People with paraplegia (PP) and tetraplegia (TP) have reduced exercise capacity due to paralysis/paresis and reduced exercising stroke volume. TP often further reduces exercise capacity due to lower maximum heart-rate and respiratory function. There is strong, consistent evidence that exercise can improve cardiorespiratory fitness and muscular strength in people with SCI. There is emerging evidence for a range of other exercise benefits, including reduced risk of cardio-metabolic disease, depression and shoulder pain, as well as improved respiratory function, quality-of-life and functional independence. Exercise recommendations for people with SCI are: ≥30min of moderate aerobic exercise on ≥5d/week or ≥20min of vigorous aerobic ≥3d/week; strength training on ≥2d/week, including scapula stabilizers and posterior shoulder girdle; and ≥2d/week flexibility training, including shoulder internal rotators. These recommendations may be aspirational for profoundly inactive clients and stratification into "beginning", "intermediate" and "advanced" will assist application of the recommendations in clinical practice. Flexibility exercise is recommended to preserve upper limb function but may not prevent contracture. For people with TP, Rating of Perceived Exertion may provide a more valid indication of exercise intensity than heart rate. The safety and effectiveness of exercise interventions can be enhanced by initial screening for autonomic dysreflexia, orthostatic hypotension, exercise-induced hypotension, thermoregulatory dysfunction, pressure sores, spasticity and pain.

1. Background

Spinal cord injury (SCI) refers to damage to neural elements of the spinal canal (spinal cord, cauda equina and spinal nerves), frequently resulting in permanent impairments of motor, sensory and/or autonomic function[1,2]. Aetiology may be traumatic (e.g., motor vehicle accident and falls) or non-traumatic (e.g., myelomengiocele, spinal stenosis, transverse myelitis and tumor) [2].

Spinal cord injury profoundly affects functioning at the level of body systems (e.g., neuromusculoskeletal and cardiovascular functioning), person (e.g., walking, grasping, lifting and carrying) and society (e.g., employment, sports participation, social engagement) [3]. It is extremely costly in human, social and economic terms[3]. The global incident rate of SCI is estimated at 23 cases per million (179,312 cases per annum), although there is considerable regional variation, from North America (40 per million) to Australia (15 per million) [3]. Globally, the incidence of SCI is highest among males aged 18-32 years and, in developed countries with ageing populations, people over 65 years[3]. Worldwide, more than 2 million people live with an SCI[3]. Given the high cost, geographic spread and relatively high incidence of SCI, evidence-based methods which improve outcomes for people with SCI are critical.

Physical activity is defined as "any bodily movement produced by skeletal muscle that results in caloric expenditure"[4]. Exercise is a specific type of physical activity that is planned, structured and repetitive and done to improve or maintain fitness[4]. Evidence indicates that people with SCI are profoundly inactive [5] and this inactivity is causally linked to an increased risk of preventable diseases that compound the primary effects of SCI[6,7]. Exercise interventions are an effective means of increasing physical activity and reducing preventable disease risk in people with SCI [7]. Additionally, specific types of exercise have been shown to enhance health, fitness and functioning in people with SCI. The aim of this Position Statement is to provide practitioners with evidence-based recommendations for prescription of safe, effective exercise interventions for adults with chronic SCI ($\geq$ six months post-injury). Between 70%[8] and 84%[9] of people with SCI use a hand-rim propelled wheelchair, and therefore they are the primary focus of this statement, although much of the information provided is relevant to people with SCI who have more severe activity limitations (e.g., people who use power wheelchairs) as well as less severe (e.g., people with SCI who walk). The Statement focuses on exercise using voluntarily activated muscles rather than assistive technology such as, Functional Electrical Stimulation and Body Weight Supported Treadmill Training. Practitioners interested in these two modalities are directed to recent reviews cited in the reference list[10,11].

2. Motor, sensory and autonomic effects of SCI

The extent of motor, sensory and autonomic dysfunction resulting from SCI depend upon the segmental level of the injury and the completeness of the injury[12]. Tetraplegia (preferred to quadriplegia) refers to injury to any of the spinal segments from C1 to C8 and results in impairments of arm, trunk and leg function[1]. Paraplegia (PP) refers to injury in the thoracic, lumbar or sacral segments, while arm function is spared. Approximately 53% of SCI results in tetraplegia (TP) and 47% in PP[12].

Motor and sensory completeness of an SCI is classified according to the American Spinal Injury Association (ASIA) Impairment Scale (AIS)[1]. There are five AIS classifications, from AIS A (complete, no motor or sensory function in sacral segments S4-S5) to AIS E (a person with initial deficits who has normal motor and sensory function at the time of assessment)[1]. The AIS scale does not include assessment of autonomic completeness, which must be assessed separately[13]. As acute management of SCI improves, the proportion of incomplete SCI is increasing[14]. Approximately 65% of SCI are incomplete, with incomplete TP (38%) being more common than incomplete PP (27%)[12].

Table 1 presents the motor, sensory and autonomic function typical of a person with an AIS A injury (i.e., motor and sensory complete) that is also autonomically complete. The third column presents the typical profile of a person whose lowest intact segmental level is C1, C2 or C3, and each subsequent column presents the profile of a progressively lower segment or group of segments. Table 1 illustrates that complete injuries can result in an extremely wide range of functional profiles - from ventilator-dependent power wheelchair users with significant cardiorespiratory compromise, to independent walkers with no cardiovascular impairments. Table 1 also indicates that when injuries are motor, sensory and autonomically complete, functioning is generally predictable, increasing with lower segmental level of injury. However, when injuries are incomplete (i.e., AIS classification B, C or D), functioning cannot be predicted, even when segmental level is identical – a sample of people with a C4 SCI that is classified AIS C may include people who require a power wheelchair for mobility through to people who are able to walk independently. In addition to the effects of lesion level and lesion completeness, the functioning of a person with SCI is also affected by age, physical activity level and comorbidities such as spasticity, contractures and pain.

3. Exercise capacity in SCI

Many people with SCI are unable to engage in lower-limb exercise and must use upper-limb modes such as wheelchair pushing or upper-limb ergometers (e.g., arm-crank or wheelchair). This constraint is important because, compared to lower limb exercise, upper limb exercise elicits a considerably reduced cardiovascular response[15]. For example, when people without SCI perform arm cycling, maximal power output (PO_{max}) and VO_{2peak} are reduced by approximately 40% and 25% respectively compared with leg cycling[15]. Efficiency is also reduced - O_2 uptake (and therefore physical strain) for any given power output is greater for arm cycling than for leg cranking.

When exercise capacity is assessed using arm-crank ergometry, there is no significant difference between VO_{2peak} for people with or without paraplegia (PP) [15]. Parity is achieved at least partly because habitual wheelchair use leads to physiological adaptations in the upper-limb musculature of PP, reducing glycogenolysis and increasing the rate of lipid utilisation[15]. Even with the limitations inherent to upper-limb exercise, SCI athletes can achieve a high VO_{2peak} (e.g., a mean of 40ml.kg^{-1}.min^{-1} for a Paralympic wheelchair basketball team[16]).

The above evidence notwithstanding, SCI adversely affects exercise capacity for a number of reasons. Firstly, as lesion level increases, voluntarily activated muscle mass decreases (see Table 1), reducing oxidative capacity and therefore maximal oxygen uptake and maximum caloric expenditure from exercise. This effect is particularly pronounced in TP because the muscles required for arm exercise are partially paralysed in addition to paralysis of the trunk and legs[15]. Secondly, as lesion level increases, sympathetic vasoconstrictive capacity gradually diminishes, reducing venous return and, in accordance with the Frank-Starling mechanism, exercising stroke volume does not rise to the same extent as non-disabled. At submaximal exercise levels, cardiac output can be maintained by a compensatory increase in heart rate, but this is not possible during maximal exercise, reducing maximal exercise capacity.

For TP, two additional factors negatively impact on exercise capacity. The first is that, for those with absent or reduced cardiac sympathetic innervation, heart rate increases rely to a proportionally greater extent on parasympathetic withdrawal and circulating catecholamines[15], and maximal heart rate may be as low as 130bpm[15]. However, it should be noted that recent evidence suggests that even those with AIS A tetraplegia may retain autonomic function that is sufficient to improve cardiovascular responses to exercise[13]. The second negative impact is that, while respiratory function is normal or near normal in most PP (see Table 1), it is approximately 60% of normal values in TP[15]. The combination of reduced active muscle mass, impaired venous return, neurologically limited maximum heart rate and decreased respiratory function significantly reduces exercise capacity in TP compared with PP. Exercise capacity norms have been previously published: for TP, VO_{2peak} of <7.6 $ml.kg^{-1}.min^{-1}$ is poor and >16.95 $ml.kg^{-1}.min^{-1}$ is excellent[17]; for PP, VO_{2peak} of <16.5 $ml.kg^{-1}.min^{-1}$ is poor and >34.4 $ml.kg^{-1}.min^{-1}$ is excellent.

4. Benefits of Exercise

There are 2 exercise benefits for which there is very strong and consistent evidence – improved cardiorespiratory fitness (CRF) and improved muscular strength[6]. Evidence indicates that CRF of both TP and PP improves in response to upper-limb aerobic training or circuit training[16,18-20]. Resistance training also improves CRF in PP[20]. In a review of 14 exercise training studies, VO_{2peak} improved by a mean of 17.6 $\pm$ 11.2% and PO by 26.1 $\pm$ 15.6%, with a trend for greater gains in PP than TP[16].

Clinically significant changes in the strength of non-paralysed muscle groups can be achieved through resistance training and circuit training[16,18,19,21]. However evidence for enhancing the strength of partially paralysed muscles (e.g., resulting from incomplete SCI or muscle groups with partial segmental innervation) through voluntary activation is mixed (see Section 7 – Gaps in the Literature).

The remainder of this Section presents exercise benefits for which there is "emerging evidence", meaning evidence has been published in peer reviewed literature and is either supported by a plausible mechanism of action, or is consistent with findings from exercise training studies in the general population, but which may not have used optimal research design or has not been replicated. One reason that stronger evidence is not available is that the SCI population is inherently heterogeneous (due to variations in lesion level, lesion completeness and comorbidities) and prevalence in society is relatively low. These factors act as a barrier to recruitment of the large, homogeneous samples required for rigorous scientific research and generation of high-quality evidence regarding the benefits of exercise for people with SCI[22,23].

Cross-sectional evidence indicates that the cardiometabolic risk profile of people with SCI who regularly perform aerobic exercise is significantly better than in those who do not: BMI and percentage fat mass are lower, total daily energy expenditure is higher and both lipid profile and glucose homeostasis are better[24,25]. Aerobic exercise interventions confer clinically important improvements in lipid lipoprotein and glucose homoeostasis[7,18]. Exercise interventions can augment weight reduction induced by caloric restriction[7], but to date, exercise interventions alone have not been shown to improve body composition or reduce weight in people with SCI[18].

In people with TP, reduced respiratory function limits exercise capacity and increases the risk of pulmonary infection. Evidence indicates that specific training techniques for inspiratory[26,27] and expiratory muscles[28] can improve respiratory function and may improve peak exercise response[27]. Sufficiently intense aerobic exercise training ($\geq$70% maximum heart rate) may improve elements of respiratory function[29].

Research indicates exercise may enhance functional independence and activities of daily living in people with SCI[23,30]. Furthermore, higher CRF is strongly correlated with increased participation in activities of daily living such as cleaning and wheeling[30].

The rate of depression among people with SCI is four times that of the general population[31] and health-related quality of life (HRQOL) is significantly lower[32]. Exercise interventions can decrease depression[33,34] and increase quality of life[33,34] in people with SCI. Moreover, people with SCI who are exercise regularly are likely to have greater life satisfaction than those who do not[35].

SCI is associated with sublesional osteopenia and osteoporosis, leading to increased fracture risk[36]. Cross-sectional studies have demonstrated that physically active TP[37] and PP[38] have significantly better sublesional and general bone health than their inactive counterparts, suggesting that regular exercise may maintain bone health.

Neuropathic pain affects 65-85% of people with SCI and may result from peripheral, spinal or cerebral mechanisms[39]. Additionally, upper-limb pain of musculoskeletal origin affects 50-70% of people with SCI [40], and it is hypothesised that it is primarily due to constant use of the arms for transfers and wheelchair propulsion[40]. However the hypothesis does not explain why non-athletes are twice as likely to develop shoulder pain as athletes[41]. Higher muscular strength is associated with less upper-limb pain in both TP and PP[42], and appropriate strength and flexibility training (e.g., strengthening scapula stabilisers and rotator cuff) has been shown to reduce shoulder pain in both groups[40,43]. A randomised controlled trial of a combined aerobic and resistance training exercise program (60-90min per session, two sessions per week for nine months) found that, compared to a control group, the intervention group significantly reduced general pain scores and depression[44].

5. Exercise Guidelines

As indicated at the beginning of Section 4, to date, the relatively low prevalence of SCI and the inherent heterogeneity of the SCI population have adversely affected the quality and quantity of exercise training evidence in people with SCI. Consequently, if exercise guidelines were to be based solely on SCI-specific exercise training evidence, they would be correspondingly weak. Importantly however, the SCI-specific evidence presented in Section 4 is consistent with findings in the general population for which there is evidence of the very highest level. Specifically, exercise training positively influences CRF, cardiometabolic risk profile, strength, mental health, bone health and physical functioning. This consistency indicates that, in the absence of compelling evidence to the contrary, exercise guidelines for people with SCI should be consistent with those for the general population. Therefore, the aerobic, strength and flexibility exercise recommendations presented in Table 2 are generally consistent with those for the general population but, where available, incorporate SCI-specific evidence. This approach is consistent with the approach adopted by reputable, international health authorities[45-47] for the development of exercise recommendations for people with disabilities, as well as one other recently published exercise guideline for people with SCI[7].

Aerobic exercise recommendations presented in Table 2 are more than 3 times the minimum volume of aerobic activity recommended for people with SCI in 2011 by Martin Ginis et al[6]. These guidelines have recently been re-published[48] and recommend a minimum volume of 20 min of moderate intensity activity, 2x/week (i.e., 40 min/week)[6,48]. In the general population there is unequivocal evidence of a dose-response relationship between aerobic exercise volume (dose) and reduced risk of morbidity and mortality (response)[49]. The relationship is curvilinear, such that reductions in morbidity and mortality that are conferred by a given increase in exercise volume are greatest for people completing very low volumes of exercise (e.g., <30min per week)[49]. The best available evidence indicates that this feature of the dose response relationship can be generalised to people with disabilities, including people with SCI [45-47]. Consequently, the risk of morbidity and mortality – including all-cause mortality, hypertension, coronary heart disease, type 2 diabetes mellitis, stroke, breast and colon cancer and depression [7,45-47,49] – is likely to be significantly higher in people with SCI who complete only 40min/week of moderate intensity aerobic activity (recommended in the Martin Ginis guidelines), compared to those who habitually complete 150min/week, as recommended in this Position Statement.

One possible reason for the discrepancy between recommendations is that this Position Statement is aimed at professional practitioners with the capacity to stratify clients into "Beginning Clients", "Intermediate Clients" and "Advanced Clients" (guidelines for stratification are described later in this section) and then apply the evidence-based recommendations appropriately in the clinical context. In contrast, the Martin Ginis guidelines are aimed at the general population of people with an SCI, providing population-level recommendations which are "appropriate for all healthy adults with chronic spinal cord injury, traumatic or non-traumatic, including tetraplegia and paraplegia…[6]"

These different aims notwithstanding, practitioners should be aware that the best available evidence indicates the following[7,45-47]: compared with a sedentary lifestyle, people with SCI who habitually complete the volume of aerobic activity recommended by Martin Ginis[6] will significantly lower health-related morbidity and mortality risk; and the volume of aerobic activity recommended in this Position Stand (Table 2) will confer a reduction in health-related morbidity and mortality that is significantly greater than the reduction conferred by the Martin Ginis recommendations[6] and which is much closer to the level of risk considered acceptable for the general population.

Recommendations for strength exercise are consistent with those recently published by the World Health Organisation[45] and one SCI-specific guideline[7]. Our recommendations for flexibility exercises are based on two SCI-specific publications[7,50], together with evidence from the general population[4].

In order to apply the recommendations presented in Table 2, practitioners should stratify clients with SCI into 3 broad categories:

1. *Beginning Clients* are not currently completing the recommended exercise volume for good health and, based on a conventional and safe rate of exercise progression[4], will be unlikely to reach that exercise volume in the next three months. A high proportion of clients will fall into this group[5], many with TP and/or multiple comorbidities. Even modest increases in exercise volume (e.g., 5min of moderate intensity activity per day) can meaningfully reduce disease risk in Beginning Clients [49];
2. *Intermediate clients* are not currently completing the recommended exercise volume for good cardiometabolic health but, based on conventional and safe rates of exercise progression[4], will be likely to reach that exercise volume in the next three months. Although the exercise recommendations in Table 2 are somewhat arbitrary, strong scientific evidence substantiates that this volume of exercise will confer a broad spectrum of significant health benefits[7,49];
3. *Advanced clients* are currently meeting or exceeding the recommended exercise volume for good health. While the number of clients in this stratum is small, it is likely that practitioners will have contact with these clients because they are more likely to seek out expertise. Evidence from the general population indicates that when exercise volumes reach extremely high levels (e.g., Ironman competitors) additional increases in exercise volume can increase health risk including the risk of musculoskeletal injury[49]. Given the high incidence of overuse-related upper-limb pain and dysfunction in people with SCI, practitioners working with clients in this stratum must be aware of clinical practice guidelines for preservation and optimisation of upper-limb function in people with SCI[50].

6. Special Considerations

Thorough pre-participation screening will identify relevant SCI-specific special considerations for exercise. Key considerations are presented below. While the range is substantial, it should be noted that a review of supervised exercise training studies found that, providing proper precautions were taken, adverse events during exercise training were not common and those that occurred were not serious[51].

SCI Aetiology may have significant exercise implications. Traumatic SCI (frequently associated with limb and brain trauma) and non-traumatic causes of SCI (e.g., spina bifida, vascular malformation or spinal stenosis) [52] may affect exercise physiology and/or biomechanics. Practitioners should be aware that SCI may not be the only (or even the major) impairment affecting exercise.

Time since injury is associated with a significant decrease in physical functioning and increase in comorbidities[53]. Exercise can ameliorate these declines but exercise-associated risk is increased [53]. Practitioners should individually tailor exercise interventions and be conservative with exercise progression.

Muscular paralysis substantially reduces the range of exercises that are possible for people with SCI. Therefore, practitioners should work cooperatively with the client to identify the core movements or activities the client can and cannot do. Assessment outcomes should include observations regarding client safety, exercise proficiency and any assistance or adapted equipment that he/she may require. The website https://www.physiotherapyexercises.com/, is an excellent resource, providing more than 300 aerobic, strength and flexibility exercises adapted for people with SCI. A compendium of the energy cost of 63 wheelchair-based activities can assist practitioners to prescribe activities of appropriate intensity[54].

Tenodesis grip is used by people with TP in the absence of voluntary grasp. This grip is initiated by active wrist extension which induces passive flexion of the fingers and thumb to produce a functional grip[55]. The strength and effectiveness of this grip is principally determined by the passive length-tension characteristics of the extrinsic finger and thumb flexors. Practitioners should assess the strength of this grip and be aware that its effectiveness will be reduced if the finger and thumb flexors are regularly stretched[4,55].

Autonomic dysreflexia (AD): AD affects individuals with SCI at T6 or above[56] and results from a noxious afferent stimulus below the level of the lesion (e.g., over-distended bladder)[56]. Symptoms may be mild or extreme (e.g., blood pressure (BP) of 300/220, pounding headache, blurred vision) and can lead to stroke, seizures and death. In Australia, people at risk of AD are usually well educated regarding symptoms and carry an "Autonomic Dysreflexia Medical Emergency Card" with information on treatment and emergency contact details. Emptying the bladder prior to exercise can minimise risk[4]. Management involves identifying and removing the noxious stimulus (e.g., occluded catheter), loosening tight stockings/bindings and sitting upright in order to minimise intracranial BP[55,56]. AD is an absolute contraindication for exercise training[16].

Orthostatic hypotension (OH) is a decrease of ≥ 20mmHg in systolic BP, or 10mmHg in diastolic BP upon sitting up from a supine position[57]. It is caused by blood pooling in the abdominal viscera and legs during lying, compounded by lack of muscular contraction during the postural change[57]. Exertional hypotension (EH) is a decrease of ≥10mmHg in systolic BP during exercise[58], and occurs due to a combination of vasodilation in exercising musculature and inadequate vasoconstriction in the splanchnic bed and non-exercising musculature[58]. Both EH and OH result in similar symptoms – light-headedness, dizziness and syncope - and both are best treated with recumbency, leg elevation and fluid ingestion[4]. Risk management includes slow, controlled positional change, a graduated introduction exercise, and BP monitoring. Regular exercise may improve tolerance of OH[59]. Symptomatic hypotension (e.g., dizziness, nausea, pallor) is an absolute contraindication for exercise training[16].

Thermoregulatory function may be impaired. In hot conditions, inability to sweat and dilate superficial vasculature impairs heat loss during exercise, particularly in TP[60] and, consequently, exercising core temperatures tend to be higher[16]. Normal precautions against overheating can be complemented by hand cooling[61], foot cooling[62], ice vests[63] and spray bottles[64]. In cold conditions, impaired superficial vasoconstriction, shiver response and piloerection accelerate heat loss, increasing the risk of exposure[60].

Sensory impairment increases the risk of pressure sores and falls (through decreased proprioception) and can delay detection/diagnosis of serious injury (e.g., bony fractures) following collisions or falls. Sensation-related risk is increased with new activities, particularly those done out of the regular chair (e.g., on new exercise equipment or a new sports wheelchair); contact sports; and when atrophy is severe. Risk management strategies include clear identification of insensate areas via client self-report; clients using their own cushions where possible/practical; thorough skin checks for red areas following new activities; regular pressure relief during exercise (every 15-30min)[55]; and appropriate protective sports equipment[55]. Some evidence indicates that a healthy lifestyle, including exercise, is protective against recurrent pressure sores[65].

Spasticity is defined as a velocity dependent increase in muscle tone and hyperexcitability of the stretch reflex[66] which can result in involuntary activation of paralysed muscles that is intermittent (spasm) or sustained. Approximately 80% of people with SCI are affected. Spasticity is associated with pain and contracture[66]. Slow controlled positional changes may reduce the likelihood of eliciting muscle spasms, and stable positioning (including strapping) can reduce the likelihood of an adverse event should spasm occur. While some limited evidence suggests stretch may provide short-term, temporary relief from spasticity, there is no high-quality evidence to suggest that these benefits are long lasting[67].

Table 3 presents medications commonly used in the management of SCI. These medications are usually taken on a stable long-term basis, and so people have often adapted to side effects. Some medications used by people with SCI can potentially enhance exercise performance (e.g., Midodrine) and are therefore on the World Anti-Doping Authority (WADA) banned list. People using such medications for therapeutic reasons may take part in competitive sport to the highest levels provided they apply for Therapeutic Use Exemption (TUE).

7. Gaps in the literature

As indicated, the exercise guidelines presented in Section 5 are based on the dose-response relationship between physical activity and disease-risk in the general population. This approach is necessary because previously mentioned research design problems frequently weaken evidence produced by SCI-specific exercise training studies, but also because exercise dose is frequently poorly documented[22]. Multi-centre trials which permit recruitment of sufficiently large, homogeneous samples of people with SCI are required to address this problem[22].

Current best practice for increasing strength in partially paralysed muscles adapts established strength training principles, typically commencing with unresisted, gravity eliminated movements, progressing to gravity opposed movements and finally to gravity opposed movements with resistance[55]. Recent evidence has demonstrated that circuit training elicited strength gains in people with TP[19]. However emerging evidence indicates that non-paralysed and partially paralysed muscles may respond differently to resistance training. For example, one study found that progressive resistance training of partially paralysed wrist extensor muscles did not enhance wrist strength[68]. Another study demonstrated that an isometric protocol which induced fatigue-related decreases in peak volitional torque in non-paralysed muscle, increased peak volitional torque in partially paralysed muscle[69]. Evidence is not strong enough to discontinue current best practice, but practitioners should be aware of its possible limitations, inform their clients and stay abreast of research developments.

Contractures are a common complication of SCI characterised by marked limitations in passive ROM of affected joints[70]. Contracture has a significant impact on activities of daily living and positioning for exercise, and is associated with pressure sores, sleep disturbances and pain[70]. Stretch and passive movements are widely used for the treatment and prevention of contractures, however, evidence demonstrating the effectiveness of these interventions is lacking, especially when only administered for short periods of time[70]. Given the severe consequences of contractures, the flexibility guidelines described in Section 5 (Exercise Guidelines) should be followed. However, practitioners should be aware of its possible limitations, inform their clients and stay abreast of research developments.

8. Summary

SCI and its co-morbidities adversely affect health, fitness and functioning, effects that are frequently compounded by profoundly sedentary behaviour. Exercise interventions have been shown to enhance health, fitness and functioning. Exercise capacity is reduced in all people with SCI, but particularly in people with TP. Strong, consistent evidence demonstrates that exercise improves CRF and muscular strength and there is emerging evidence for a range of other benefits (e.g., reduced risk of cardio-metabolic disease, depression and shoulder pain, and improved functional independence). People with SCI should complete ≥30min of moderate aerobic exercise on ≥5d/week or ≥20min of vigorous aerobic ≥3d/week; strength training on ≥2d/week, including scapula stabilizers and posterior shoulder girdle; and ≥2d/week flexibility training, including shoulder internal rotators. These recommendations may be aspirational for profoundly inactive clients and stratification of clients into "beginning", "intermediate" and "advanced" will assist practitioners to apply the recommendations appropriately in clinical practice and tailor programs accordingly. Flexibility exercise is recommended to preserve upper limb function but may not prevent contracture. The safety and effectiveness of exercise interventions can be enhanced by initial screening for AD, OH, EH, thermoregulatory dysfunction, pressure ulcers, spasticity and pain.

References

1. Kirshblum SC, Burns SP, Biering-Sorensen F, et al. International standards for neurological classification of spinal cord injury (revised 2011). *J Spinal Cord Med.* Nov 2011;34(6):535-546.
2. New PW, Marshall R. International Spinal Cord Injury Data Sets for non-traumatic spinal cord injury. *Spinal Cord.* Feb 2014;52(2):123-132.
3. Lee BB, Cripps RA, Fitzharris M, et al. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. *Spinal Cord.* Feb 26 2013.
4. American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription.* 9th ed. Philadelphia: Lippincott Williams and Wilkins; 2013.
5. Buchholz AC, McGillivray F, Pencharz PB. Physical Activity Levels Are Low In Free-Living Adults with Chronic Paraplegia. *Obes Res.* 2003;11(4):563-570.
6. Martin Ginis KA, Hicks AL, Latimer AE, et al. The development of evidence-informed physical activity guidelines for adults with spinal cord injury. *Spinal Cord.* Nov 2011;49(11):1088-1096.
7. Kressler J, Cowan RE, Bigford GE, et al. Reducing cardiometabolic disease in spinal cord injury. *Phys Med Rehabil Clin N Am.* Aug 2014;25(3):573-604, viii.
8. Florio J, Arnet U, Gemperli A, et al. Need and use of assistive devices for personal mobility by individuals with spinal cord injury. *J Spinal Cord Med.* Dec 14 2015. doi:10.1080/10790268.2015.1114228

9. Biering-Sorensen F, Hansen RB, Biering-Sorensen J. Mobility aids and transport possibilities 10-45 years after spinal cord injury. *Spinal cord.* Dec 2004;42(12):699-706.

10. Davis GM, Hamzaid NA, Fornusek C. Cardiorespiratory, metabolic, and biomechanical responses during functional electrical stimulation leg exercise: health and fitness benefits. *Artificial Organs.* 2008;32(8):625-629.

11. Mehrholz J, Kugler J, Pohl M. Locomotor training for walking after spinal cord injury. *The Cochrane Database Syst Rev.* 2012;11:CD006676.

12. Norton L. *Spinal Cord Injury, Australia 2007-08.* Canberra: Australian Institute of Health and Welfare; 2010.

13. West CR, Bellantoni A, Krassioukov AV. Cardiovascular function in individuals with incomplete spinal cord injury: a systematic review. *Top Spinal Cord Inj Rehabil.* Fall 2013;19(4):267-278.

14. Devivo MJ. Epidemiology of traumatic spinal cord injury: trends and future implications. *Spinal Cord.* May 2012;50(5):365-372.

15. Theisen D. Cardiovascular determinants of exercise capacity in the Paralympic athlete with spinal cord injury. *Exp Physiol.* 2012;97(3):319-324.

16. Figoni SF, Kiratli BJ, Sasaki R. Spinal Cord Dysfunction. In: Myers J, Nieman DC, American College of Sports Medicine, eds. *ACSM's Resources for Clinical Exercise Physiology: musculoskeletal, neuromuscular, neoplastic, immunologic, and hematologic conditions.* Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2010.

17. Janssen TW, Dallmeijer AJ, Veeger DJ, et al. Normative values and determinants of physical capacity in individuals with spinal cord injury. *J Rehabil Res Dev.* Jan-Feb 2002;39(1):29-39.

18. Hicks AL, Martin Ginis KA, Pelletier CA, et al. 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.* Nov 2011;49(11):1103-1127.

19. Kressler J, Burns PA, Betancourt L, Nash MS. Circuit training and protein supplementation in persons with chronic tetraplegia. *Med Sci Sports Exerc.* Jul 2014;46(7):1277-1284.

20. Jacobs PL, Nash ML, Rusinowski JW. Circuit Training Provides Cardiorespiratory and Strength Benefits in Persons with Paraplegia. *Med Sci Sports Exerc.* 2001;33:711-717.

21. Jacobs PL. Effects of resistance and endurance training in persons with paraplegia. *Med Sci Sports Exerc.* May 2009;41(5):992-997.

22. Silverman SR, Schertz LA, Yuen HK, et al. Systematic review of the methodological quality and outcome measures utilized in exercise interventions for adults with spinal cord injury. *Spinal Cord.* Oct 2012;50(10):718-727.

23. Duran FS, Lugo L, Ramirez L, et al. Effects of an exercise program on the rehabilitation of patients with spinal cord injury. *Arch Phys Med Rehabil.* Oct 2001;82(10):1349-1354.

24. Warburton DER, Sproule S, Krassioukov A, et al. Cardiovascular Health and Exercise Following Spinal Cord Injury. In: Eng JJ, Teasell RW, Miller WC, et al, ed. *Spinal Cord Injury Rehabilitation Evidence.* Version 4.0 ed: Vancouver; 2012:1-43.

25. Tanhoffer RA, Tanhoffer AI, Raymond J, et al. Exercise, energy expenditure, and body composition in people with spinal cord injury. *J Phys Act Health.* Sep 2014;11(7):1393-1400.

26. Mueller G, Hopman MT, Perret C. Comparison of respiratory muscle training methods in individuals with motor and sensory complete tetraplegia: a randomized controlled trial. *J Rehabil Med* Mar 6 2013;45(3):248-253.

27. West CR, Taylor BJ, Campbell IG, et al. Effects of inspiratory muscle training on exercise responses in Paralympic athletes with cervical spinal cord injury. *Scand J Med Sci Sports.* Oct 2014;24(5):764-772.

28. Schilero GJ, Spungen AM, Bauman WA, et al. Pulmonary function and spinal cord injury. *RespirPhysiol Neurobiol.* May 15 2009;166(3):129-141.

29. Sheel AW, Reid WD, Townson A, et al. Respiratory Management. In: Eng JJ, Teasell RW, Miller WC, et al. *Spinal Cord Injury Rehabilitation Evidence*. Version 4.0 ed: Vancouver; 2012:1-51.

30. Hetz SP, Latimer AE, Ginis KA. Activities of daily living performed by individuals with SCI: relationships with physical fitness and leisure time physical activity. *Spinal Cord.* Jul 2009;47(7):550-554.

31. Krause JS, Kemp B, Coker J. Depression after spinal cord injury: relation to gender, ethnicity, aging, and socioeconomic indicators. *Arch Phys Med Rehabil.* Aug 2000;81(8):1099-1109.

32. Lidal IB, Veenstra M, Hjeltnes N, et al. Health-related quality of life in persons with long-standing spinal cord injury. *Spinal Cord.* Nov 2008;46(11):710-715.

33. Hicks AL, Martin KA, Ditor DS, et al. Long-term exercise training in persons with spinal cord injury: effects on strength, arm ergometry performance and psychological well-being. *Spinal Cord.* Jan 2003;41(1):34-43.

34. Ginis KA, Latimer, A.E., McKechnie, K., et al. Using exercise to enhance subjective well-being among people with spinal cord injury: The mediating influences of stress and pain. *Rehabil Psychol.* 2003;48(3):157-164.

35. Stevens SL, Caputo, J.L., Fuller, D.K., et al. Physical activity and quality of life in adults with spinal cord injury. *J Spinal Cord Med.* 2008;31:373-378.

36. Giangregorio L, McCartny, N. Bone loss and muscle atrophy in spinal cord injury: epidemiology, fracture prediction, and rehabilitation strategies. *J Spinal Cord Med.* 2006;29(5):489-500.

37. Chain A, Koury JC, Bezerra FF. Physical activity benefits bone density and bone-related hormones in adult men with cervical spinal cord injury. *Eur J Appl Physiol.* Sep 2012;112(9):3179-3186.

38. Miyahara K, Wang DH, Mori K, et al. Effect of sports activity on bone mineral density in wheelchair athletes. *J Bone Miner Metab.* 2008;26(1):101-106.

39. Siddall PJ. Management of neuropathic pain following spinal cord injury: now and in the future. *Spinal Cord.* May 2009;47(5):352-359.

40. Teasell RW, Mehta S, Wolfe DL, Hesieh JTC, Short C. Pain Following Spinal Cord Injury. In: Eng JJ, Teasell RW, Miller WC, et al. *Spinal Cord Injury Rehabilitation Evidence.* Version 4.0 ed: Vancouver; 2012:1-43.

41. Fullerton HD, Borckardt JJ, Alfano AP. Shoulder pain: a comparison of wheelchair athletes and nonathletic wheelchair users. *Med Sci Sports Exerc.* Dec 2003;35(12):1958-1961.

42. van Drongelen S, de Groot S, Veeger HE, et al. Upper extremity musculoskeletal pain during and after rehabilitation in wheelchair-using persons with a spinal cord injury. *Spinal Cord.* Mar 2006;44(3):152-159.

43. Van Straaten MG, Cloud BA, Morrow MM, et al. Effectiveness of home exercise on pain, function, and strength of manual wheelchair users with spinal cord injury: a high-dose shoulder program with telerehabilitation. *Arch Phys Med Rehabil.* Oct 2014;95(10):1810-1817 e1812.

44. Ditor DS, Latimer AE, Ginis KA, et al. Maintenance of exercise participation in individuals with spinal cord injury: effects on quality of life, stress and pain. *Spinal Cord.* Aug 2003;41(8):446-450.

45. World Health Organization. *Global Recommendations on Physical Activity for Health.* Geneva, Switzerland: Author; 2013.

46. Physical Activity Guidelines Advisory Committee. Understudied Populations (Part G. Section 11). In: Physical Activity Guidelines Advisory Committee, ed. *Physical Activity Guidelines Advisory Committee Report 2008*. Washington, DC: US DHHS; 2008:683.

47. Academy of Royal Medical Colleges. Exercise-the miracle cure. 2015:1-59.Available at http://www.aomrc.org.uk/general-news/exercise-the-miracle-cure.html. Accessed 2 January 2016

48. Evans N, Wingo B, Sasso E, et al. Exercise Recommendations and Considerations for Persons With Spinal Cord Injury. *Arch Phys Med Rehabi.* Sep 2015;96(9):1749-1750.

49. Powell KE, Paluch AE, Blair SN. Physical activity for health: What kind? How much? How intense? On top of what? *Annu Rev Public Health.* 2011;32:349-365.

50. Consortium for Spinal Cord Medicine. Preservation of upper limb function following spinal cord injury: a clinical practice guideline for health-care professionals. *J Spinal Cord Med.* 2005;28(5):434-470.

51. Warms CA, Backus D, Rajan S, et al. Adverse events in cardiovascular-related training programs in people with spinal cord injury: a systematic review. *J Spinal Cord Med.* Nov 2014;37(6):672-692.

52. Nott MT, Baguley IJ, Heriseanu R, et al. Effects of concomitant spinal cord injury and brain injury on medical and functional outcomes and community participation. *Top Spinal Cord Inj Rehabil.* Summer 2014;20(3):225-235.

53. Charlifue S, Jha A, Lammertse D. Aging with spinal cord injury. *Phys Med Rehabil Clin N Am.* May 2010;21(2):383-402.

54. Conger SA, Bassett DR. A compendium of energy costs of physical activities for individuals who use manual wheelchairs. *APAQ.* Oct 2011;28(4):310-325.

55. Harvey L. *Management of Spinal Cord Injuries: a guide for physiotherapists.* New York: Butterworth-Heinemann; 2008.

56. Krassioukov A, Blackmer J, Teasell RW, et al. Autonomic Dysreflexia Following Spinal Cord Injury. In: Eng JJ Teasell RW, Miller WC, et al. *Spinal Cord Injury Rehabilitation Evidence.* Version 4.0 ed: Vancouver; 2012:1-31.

57. Claydon VE, Steeves JD, Krassioukov A. Orthostatic hypotension following spinal cord injury: understanding clinical pathophysiology. *Spinal Cord.* Jun 2006;44(6):341-351.

58. Low DA, da Nobrega, ACL., Mathias, CJ. Exercise-induced hypotension in autonomic disorders. *Auton Neurosci.* 2012;171:66-78.

59. Otsuka Y, Shima N, Moritani T, et al. Orthostatic influence on heart rate and blood pressure variability in trained persons with tetraplegia. *Eur J Appl Physiol.* Sep 2008;104(1):75-78.

60. Krassioukov A. Autonomic function following cervical spinal cord injury. *Respir Physiol Neurobiol.* Nov 30 2009;169(2):157-164.

61. Goosey-Tolfrey V, Swainson, M., Boyd, C., et al. The effectiveness of hand cooling at reducing exercise-induced hyperthermia and improving distance-race performance in wheelchair and able-bodied athletes. *J Appl Physiol.* 2008;105(1):37-43.

62. Hagobian TA, Jacobs, K.A., Kiratli, B.J., et al. Foot cooling reduces exercise-induced hyperthermia in men with spinal cord injury. *Med Sci Sports Exerc.* 2004;36(3):411-417.

63. Webborn N, Price, M.J., Castle, P.C., et al. Effects of two cooling strategies on thermoregulatory responses of tetraplegic atheltes during repeated intermittant exercise in the heat. *J Appl Physiol.* 2005;98(6):2101-2107.

64. Pritchett RC, Bishop, P.A., Yang, Z., et al. Evaluation of artificial sweat in atheltes with spinal cord injuries. *Eur J Appl Physiol.* 2010;109(1):125-131.

65. Krause JS, Broderick L. Patterns of recurrent pressure ulcers after spinal cord injury: identification of risk and protective factors 5 or more years after onset. *Arch Phys Med Rehabil.* Aug 2004;85(8):1257-1264.

66. Strommen JA. Management of spasticity from spinal cord dysfunction. *Neurol Clin.* Feb 2013;31(1):269-286.

67. Harvey LA, Herbert RD, Glinsky J, et al. Effects of 6 months of regular passive movements on ankle joint mobility in people with spinal cord injury: a randomized controlled trial. *Spinal Cord.* Jan 2009;47(1):62-66.

68. Glinsky J, Harvey L, Korten M, et al. Short-term progressive resistance exercise may not be effective at increasing wrist strength in people with tetraplegia: a randomised controlled trial. *Aust J Physiother.* 2008;54(2):103-108.

69. Jayaraman A, Thompson CK, Rymer WZ, et al. Short-term maximal-intensity resistance training increases volitional function and strength in chronic incomplete spinal cord injury: a pilot study. *JNPT.* Sep 2013;37(3):112-117.

70. Katalinic OM, Harvey LA, Herbert RD, et al. Stretch for the treatment and prevention of contractures. *Cochrane Database Syst Rev.* 2010(9):CD007455.

71. Goosey-Tolfrey V, Lenton, J., Goddard, J., et al. Regulating intensity using perceived exertion in spinal cord-injured participants. *Med Sci Sports Exerc.* 2010;42(3):608-613.

Table 1: The motor, sensory and autonomic function typical of a person with an AIS A spinal cord injury that is also autonomically complete, from C1 – S4. SCI segmental levels are indicated in the header row and indicate the lowest intact segment/s. The motor profile represents that typically attained by people who are young and otherwise healthy[24,55].

		C1-3	C4	C5	C6	C7-C8	T1-T5	T6-T12	L2-L3	L4-L5	S2-4
Voluntary Motor Function	Functional grasp	None			Reduced		Normal				
	Mobility	Power Wheelchair (mouth, chin or voice controlled)		Power wheelchair (arm/hand controlled) or hand-rim propelled Wheelchair)		Hand-rim propelled Wheelchair				Hand-rim propelled Wheelchair or walking[1] (limited)	Walking* or hand-rim propelled wheelchair (long distance)
	Transfers: Chair-bench or floor-chair	Fully dependent for both		Some assistance chair-bench; dependent floor-chair	Some assistance chair-bench and floor-chair	Independent for both					
	Lying to sitting	Dependent		Moderate assistance	Independent						
	Sitting	Dependent for quiet sitting		Moderate assistance	Independent for quiet sitting but trunk support required for exercising				Independent		
	Driving	No		Yes							
	Respiratory function	Ventilator dependent	Unassisted breathing (diaphragm)				Unassisted (diaphragm + some intercostal)	Normal or near normal	Normal		
Sensory function	Includes light touch, pain, proprioception & temperature	Present in head and neck	Present in head, neck and parts of arms				Present in head, arms and parts of the trunk		Present in head, arms, trunk and parts of the legs		

Autonomic function	Sudomotor and piloerrector function	Normal above the level of the injury and absent below the level of the injury			
	Sympathetic vasomotor function	Reduced in the arms and absent in splanchnic bed and legs	Normal in arms, absent splanchnic bed and legs	Normal in arms, reduced in splanchnic bed and absent in legs	Normal in arms and splanchnic bed, reduced in legs
	Sympathetic cardiac innervation	None	Reduced	Normal	
	Blood pressure responses	Impaired - susceptible to orthostatic hypotension (OH), exercise-induced hypotension (EH) and/or autonomic dysreflexia (AD)	Possible OH, EH or AD	Normal	

*Requires lower-limb orthoses;

Table 2: Exercise Guidelines for People with SCI. These volumes of aerobic, strength and flexibility exercise are required in order for people with SCI to achieve good cardiometabolic health, physical fitness and functioning.

Exercise component	Volume of exercise	Type	Comments
Aerobic exercise	≥30min of moderate exercise on ≥5d/week; or ≥20min of vigorous exercise on ≥3d/week; or a combination of moderate and vigorous exercise on ≥ 3-5d/week[4,7,45,46]. Can be accumulated in bouts of ≥ 10 min[7,71].	Exercise modes involving rhythmic contraction and relaxation of the largest available muscle groups. [4,23] (e.g., wheelchair pushing, hand cycling, swimming)	Moderate intensity is[4]: - 3-6 METs*; or - 12-13 on BRPE scale; or - 40-59% HRR[†]. Vigorous intensity is[4]: - 6-8.8 METs - 14-15 on BRPE scale - 60-89% HRR
Muscular strength	• ≥2d/week[4,6,7,45,46]; • Exercises covering the major muscle groups[4,6,7,45] and should incorporate, if possible, 4-5 upper-limb exercises[7]; • 3 sets of each exercise (1 set = 8-12 repetitions)[4,6,7] with 2-3 min recovery between each set[4]; • Moderate intensity (60%-70% 1RM[4,6] or 12-13 on BRPE)[4] • strengthen scapula stabilisers and muscles of posterior shoulder girdle to protect against overuse injuries[7,43]	Free weights, pin loaded weights, body weight elastic bands or tubing, hydraulic resistance.	- Innervation of scapula stabilisers and posterior shoulder girdle is normal in people with PP and progressively decreases with higher lesion level in TP [50]. - Strength movements should be pain-free where possible[50]. When pain is pre-existing, it should be monitored and exercise discontinued if pain is exacerbated; - where possible, ensure agonists and antagonists are in balance[4]; - Avoid internal shoulder rotation when in $\geq 90^0$ abduction to limit impingement[50].
Flexibility	• ≥2d/week[4,50]; • Address the major muscle groups, including those of the neck, upper limbs, trunk and lower limbs[7,50]; • hold each static stretch for 10-30 seconds and complete 60 seconds of total stretching time for each flexibility exercise (e.g.,2x30sec or 4x15sec)[4]; • static stretching (active or passive) should be done to a point in the range where there is a feeling of tightness, slight discomfort or, when sensation is impaired, to a point in the range at which resistance begins to increase [4,7]; • focus areas: stretching internal shoulder rotators[50], chest, and anterior shoulders[7,43].	Static stretching (described in this guideline) but also dynamic stretching[4].	- To limit impingement, avoid internal shoulder rotation when completing an overhead range of motion[50]; - Stretching of paralysed lower limbs in long-term wheelchair users should be conducted particularly cautiously due to increased incidence of sub-lesional osteopenia / osteoporosis.

Acronyms: MET – Metabolic equivalent; BRPE - Borg Rating of Perceived Exertion; HRR - Heart Rate Reserve

*For reasons presented in Section 3, untrained people with TP are only likely to achieve 2-3 METs;

†People with autonomically complete SCI above T6 have reduced cardiac sympathetic drive, and above T1 no sympathetic drive (see Table 1). In these clients, heart-rate based methods will not provide a valid indication of exercise intensity, but RPE can be used as a valid alternative[72]

Table 3: Medications commonly used in the management of SCI

Therapeutic Purpose	Medication name (Generic)	Side-Effects Which May Affect Exercise
Reduce spasticity	Baclofen	Nausea; CNS depression; confusion; muscle weakness or pain; hypotension.
	Dantrolene sodium	Drowsiness; dizziness; muscle weakness; fatigue
	Botox (Botulinum toxin)	Muscle weakness; oropharyngeal problems; respiratory problems; pain; gait problems and falls.
Reduce neuropathic pain	Gabapentin	Weight gain; confusion; dizziness; somnolence; ataxia; fatigue.
	Pregebalin	CNS effects include dizziness, somnolence, and insomnia; blurred vision; fatigue; weight gain.
Reduce bladder hypereflexia / spasm	Oxybutynin	Dry mouth, nausea; dizziness; drowsiness; blurred vision; asthenia (uncommon)
Relax bladder sphincter; improve bladder emptying	Prazosin	Orthostatic hypotension; syncope; drowsiness; dizziness; lack of energy; weakness.
Treat Urinary Tract Infection	Norfloxacin (antibiotic)	Nausea; headache; dizziness (all relatively uncommon).
	Sulfamethoxazole - Trimethoprim (antibiotic)	Nausea, vomiting
Treat low blood pressure/hypotension	Midodrine	Increased blood pressure; blurred vision; headache.
Prevent / treat blood clots	Warfarin sodium and other anticoagulants	Easy bruising / increased bleeding with injury
Treat impotence / erectile dysfunction	Sildenafil, Tadalafil, Vardenafil	Headache; dyspepsia; dizziness; back pain; nasal congestion; flushing.