Title:

Multidisciplinary Association for Spinal Cord Injury Professions (MASCIP) guideline for weight management in individuals with spinal cord injury.

Authors:

Samford Wong[1,2], Lorna O'Connor[3], Anthony Twist[4], Gemma Moseley[5], Ronan Langan[3], Éimear Smith[3], Allison Graham[1], Carolyn Taylor[6], Lady-Marie Dawson-Malcolm.[7], Nigel Wainworth, Shashi P Hirani[2], [10]

Acknowledgements:

[1]National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK

[2]School of Health Science, City University, London, UK

[3]National Rehabilitation Hospital, Dublin, Republic of Ireland

[4]Midland Centre for Spinal Cord Injury, Robert Jones & Agnes Hunt Orthopaedic Hospital NHS Foundation Trust, Oswestry, UK

[5]London Spinal Injuries Centre, Royal National Orthopaedic Hospital, Stanmore, UK

[6]Princess Royal Spinal Injuries Centre, Northern General Hospital, Sheffield, UK

[7]Spinal Injury Association, Milton Keynes, UK

[8]Duke of Cornwall Spinal Injuries Centre, Salisbury District Hospital, Salisbury, UK

[9]Active Assistance (Care Agency), Kent, UK

[10] Mid Yorkshire Hospitals NHS Trust, Dewsbury, UK

Correspondence address:

Samford Wong, Department of Nutrition and Dietetics, National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK HP21 8AL.

Work fax: +44 (0)1296 315049

Email: Samford.Wong@buckshealthcare.nhs.uk

Word count: 15,650

The Guideline Panel Membership

Samford Wong, National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK
Lorna O'Connor, National Rehabilitation Hospital, Dun Laoghaire, Dublin, Ireland
Anthony Twist, Midland Centre for Spinal Cord Injury, Robert Jones & Agnes Hunt Orthopaedic Hospital NHS Foundation Trust, Oswestry, UK
Gemma Moseley, London Spinal Injuries Centre, Royal National Orthopaedic Hospital, Stanmore, UK
Ronan Langan, National Rehabilitation Hospital, Dun Laoghaire, Dublin, Ireland
Carolyn Taylor, Princess Royal Spinal Injuries Centre, Northern General Hospital, Sheffield, UK
Allison Graham, National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK
Eimear Smith, National Rehabilitation Hospital, Dun Laoghaire, Dublin, Ireland
Marie Dawson-Malcom, Spinal Injury Association, Milton Keynes, UK
Shashi Hirani, School of Health Science, City University, London, UK
Nigel Wainworth, Mid Yorkshire Hospitals NHS Trust, Dewsbury, UK

Lay Summary

Obesity is becoming an increasing problem within the spinal cord injury (SCI) population as life expectancy continues to increase. This is the same for the whole population, but the impact on the SCI person is greater as it can also affect their mobility and increase the risk of other problems such as pressure ulcers. Obesity has also been associated with increasing the risk of Diabetes and Heart Disease and both conditions are associated with an increased prevalence in SCI.

Due to altered body composition associated with SCI it was important to review the evidence to establish energy requirements, the effects of increasing levels of obesity, appropriate diets and exercise programmes to recommend to those trying to lose weight. This was completed by a Panel of experts who work with SCI including Dietitians, Medical Staff, Physiotherapists, Nurses and Psychologists.

Determining the definition of what is categorised as overweight and obese in SCI is challenging as it is different than the general population. This is due to the changing body composition and loss of muscle mass below the level of injury. Body Mass Index (BMI) is frequently used and it was felt that this was a measure that was understood, however the normal range needed to be altered to reflect this changing body composition. It was agreed that a BMI greater than 22 Kg/m^2 would reflect those that are overweight. Whilst direct measurements of body composition are possible such measurements are likely to be associated with research studies rather than being used in general practice.

In line with the altered body composition, a reduction in energy needs have been associated with the increased prevalence in obesity seen in SCI. Predictive equations for estimating resting energy expenditure have been found to overestimate nutritional requirements so should be used with caution. Methods to measure accurately energy expenditure are more suited to the research environment. It is therefore important to monitor weight changes in individuals over time. Suggested methods to monitoring weight are weight, BMI, mid arm circumference, bioelectrical impedance and waist circumference.

Evidence suggests that weight loss is possible in SCI and any programme to support this loss would need to include dietary advice, exercise recommendations and behaviour change techniques. The rate of weight loss is important to ensure that health is not impacted by rapid weight loss. This is particularly important to ensure continued skin integrity. A weight loss of 0.5-1Kg per weight was recommended.

A variety of diets were considered and included calorie reduction, advice on portion sizes, very low calorie diets and meal replacements. These were all considered to be possible diets. A calorie intake of 600kcal below requirements was considered to be suitable for promoting weight loss. There was consensus that those on very low calorie diets (600-800 total calories per day) would need to have dietetic support to ensure the diet remained balanced in all nutrients and be only used as part of a multicomponent weight management plan. Surgical and medical options were considered to be possible for those with a BMI greater than $35Kg/m^2$. The reduction on absorption of food following these interventions may affect bowel habits and should be considered as to whether it is appropriate for an individual.

Where possible, exercise of 150 mins per week should be encouraged to support weight loss. This should be appropriate to the level of disability and may require input from a physiotherapist for further advice.

Overall it was considered that weight management is a challenge for people with a SCI due to reduced energy expenditure and reduced mobility. However, with support, a dietary intervention, exercise advice and behavioural change techniques, weight loss is possible.

Abstract

Introduction: Obesity has increasingly become a health concern for people with a Spinal Cord Injury (SCI), partly due to enforced inactivity secondary to paralysis and subsequent changes in body composition. Obesity is associated with multiple cardiovascular risk factors such as dyslipidemia, hyperinsulinemia, glucose intolerance, and hypertension. Cardiovascular disease is a major cause of morbidity in people with a SCI. Obesity also affects activities of daily living, is associated with poorer clinical outcomes and increased healthcare costs. A recent survey completed by professionals working in SCI centres suggest there is a need to develop specific weight management guidelines for people with a SCI.

Methods: An expert Panel was formed in 2014 to develop weight management guidelines for people with SCI. This included clinical dietitians, nurses, physiotherapists, psychologists and physicians working in the area of SCI rehabilitation and service users. The GRADE methodology (Grade of Recommendation, Assessment, Development and Evaluation) was used to evaluate human literatures on weight management in people with SCI between 2000 to 2013 from Medline, Embase, CINAHL, PsycINFO and the Cochrane Library.

Results: Recommendations were classified under 7 domains: (1) Classification and Indices of obesity (2) Nutritional Education and Weight Management Programmes (3) Dietary Interventions (4) Behavioural Therapy / Psychological Intervention (5) Physical Activity Interventions (6) Medical and Surgical Interventions (7) Bowel Management Implications.

Conclusion:
Weight loss is possible for people with a SCI. Early detection and intervention is recommended. Successful management of obesity in the general population incorperates a multidimodal approach including nutritional and behavioural interventions, physical activity, surgery and medications. Treatment should incorporate a similar approach tailored to the specific needs of people with a SCI.

Keywords: Obesity, Weight Management, Spinal Cord Injury.

Summary of recommendations

The following recommendations are based on available evidence. Where evidence is limited- the panel have used clinical experience and sought consensus. The overall objective is to improve the care of people with a SCI and to guide clinicians and policy makers through its recommendations. The panel based its evidence rating on research in which the focus of study was SCI, and not trials, guidelines, and expert opinions contained in scientific literature of non-SCI populations. Higher-level evidence from the general non-SCI population have been used to provide a rationale for selected panel recommendations, but not to establish the level and strength of evidence.

For individual patients, decisions are best made by considering these recommendations combined with clinical judgement, the latter based on specific knowledge about each patient's risk factor for obesity, the potential for adverse effects, and the availability of various options within SCI centres. The bracketed rating refers to the level of scientific evidence, the strength of the evidence, and the level of panel agreement with the recommendations.

- Strong consensus- agreement of >90% of the participants
- Consensus – agreement >75-90% of the participants
- Majority agreement – agreement of 50-75% of the participants
- No consensus – agreement of <50% of the participants

Summary of Recommendations (Table 1)

Classification and Indices of Overweight and Obesity

Recommendation 1

We recommend using an adjusted Body Mass Index (BMI) of 22 kg/m^2 and 25 kg/m^2 to classify overweight and obesity, estimate risk for disease, and to identify treatment options

Grade of recommendation: D; Level of agreement: Strong agreement (Median score of 8); Strong consensus (90% agreement, 95% CI 7.1 to 8.1)

Recommendation 2

Ultrasonography, Dual-Energy X-ray Absorptiometry (DEXA), Computed tomography (CT) and Magnetic Resonance Imaging (MRI) should be used to determine body composition in a research setting.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Majority consensus (60% agreement, 95% CI 5.9 to 8.1)

Nutritional Education and Weight Management Programs

Recommendation 3

Referral to a dietitian should be considered for those with a BMI >28 kg/m^2 with known metabolic syndromes such as diabetes mellitus, dyslipidemia and hypertension.

Grade of recommendation: D; Level of agreement: Strong agreement (Median score of 8); Strong consensus (80% agreement, 95% CI 6.4 to 8.4)

Recommendation 4

Weight loss and weight maintenance therapy should include a combination of calorie reduction of 600-800kcal/day, increased physical activity, and behaviour therapy.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Majority consensus (60% agreement, 95% CI 5.7 to 8.1)

Recommendation 5

Weight management programmes should be of at least 6 months duration or until weight loss goals are achieved. A weight maintenance programme should be implemented afterwards.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 6.6 to 8.0)

Recommendation 6

A greater frequency of contacts between the patients and practitioner may lead to more successful weight loss and weight maintenance.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 7.6 to 8.4)

Recommendation 7

Weight loss goals should be individualised as part of weight loss program.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 9); Strong consensus (100% agreement, 95% CI 8.6 to 9.1)

Recommendation 8

Weight loss rate should be 0.5 to 1 kg per week for the first 6 months and should aim to achieve an initial weight loss goal of up to 10% from initial body weight.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 7.5); Majority consensus (70% agreement, 95% CI 6.3 to 7.9)

Recommendation 9

The combination of a reduced calorie diet and increased physical activity is recommended as it produces weight loss. It may also result in reduced abdominal adiposity

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (90% agreement, 95% CI 7.3 to 8.5)

Recommendation 10

Telehealth can be used to provide a person with a personalised physical activity programme, dietary advice and regular coaching.

Grade of recommendation: B; Level of agreement: Agreement (Median score of 8); Strong consensus (90% agreement, 95% CI 7.0 to 8.4)

Dietary Interventions

Recommendation 11

The main requirement of a dietary approach to weight loss is that total energy intake should be less than energy expenditure. Consideration should be given to physical activity levels, energy requirements, co-morbidities, social and economic factors when choosing a dietary approach.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (88.9% agreement, 95% CI 7.6 to 8.8)

Recommendation 12

Predictive equations may overestimate Resting Metabolic Rate (RMR) in people with SCI. These need to be used with caution until an appropriate predictive equation can be found.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Majority consensus (70% agreement, 95% CI 6.9 to 8.5)

Recommendation 13

There was no evidence from this review to suggest a particular predictive equation was more accurate than another.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); majority consensus (70% agreement, 95% CI 6.3 to 8.5)

Recommendation 14

RMR appears to be lower in people with a SCI than the non-SCI population. Healthcare professionals should be made aware of this so that they can tailor their recommendations accordingly.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Strong consensus (80% agreement, 95% CI 7.2 to 8.8)

Recommendation 15

Where possible, RMR should be measured using indirect calorimetry.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Consensus (77.8% agreement, 95% CI 6.5 to 8.2)

Recommendation 16

Research is limited regarding dietary approaches to weight loss for people with a SCI. NICE guidelines recommends that diets that have a 600 kcal/day deficit (that is, they contain 600 kcal less than the person needs to stay the same weight) in addition to expert support and intensive follow-up for sustainable weight loss.
Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Strong consensus (90% agreement, 95% CI 7.0 to 8.4)

Recommendation 17

Recommendations on appropriate portion sizes of food groups as part of a calorie-controlled diet can be a useful dietary strategy used within the context of a comprehensive weight management programme. This may involve the translation of energy requirements into practical food choices and servings
Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 7.5 to 8.5)

Recommendation 18

Total caloric intake should be distributed throughout the day. This should include a healthy breakfast as part of regular balanced meals.
Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 7.5 to 8.5)

Recommendation 19

Consider low-calorie diets (800–1600 kcal/day), but be aware these are less likely to be nutritionally complete.
Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Majority consensus (70% agreement, 95% CI 6.8 to 8.4)

Recommendation 20

Meal replacements can be another dietary treatment strategy to consider as part of a comprehensive weight management programme. They may be suitable for

people who have difficulty with appropriate food selection and /or portion control. They should be used in conjunction with nutritional education and support.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 7.5); Majority consensus (60% agreement, 95% CI 6.8 to 8.2)

Recommendation 21

Do not routinely use very-low-calorie diets (VLCD) (800 kcal/day or less) to manage obesity. They should only be considered as part of a multicomponent weight management strategy. Weight maintenance strategies should be discussed on completion of a VLCD. A healthy balance diet should be advised long term.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 6.6 to 8.0)

Grade of recommendation

Behavioral Therapy / Psychological Intervention

Recommendation 22

Behavioural therapy, physical activity in combination with a caloric deficit diet, provides additional benefits in assisting patients to lose weight short term.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 7.8 to 8.4)

Recommendation 23

No one behavioural technique appeared to be superior to any other in its effect on weight loss.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 7); Strong consensus (77.8% agreement, 95% CI 6.5 to 7.9)

Physical Activity Interventions

Recommendation 24

In-patient exercise programmes should include a variety of sports as well as physiotherapy to create exposure to different ways of exercising.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Majority consensus (60% agreement, 95% CI 6.7 to 8.1)

Recommendation 25

Physical activity or exercise should aim to be 150 minutes per week spread over the week.

Grade of recommendation: C; Level of agreement: Indecision (Median score of 6); No consensus (40% agreement, 95% CI 5.4 to 7.0)

Recommendation 26

People with a SCI should be also encouraged to incorporate 25 minutes of leisure time physical activity per day as part of a healthy lifestyle.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 7); Majority consensus (66.7% agreement, 95% CI 5.8 to 7.6)

Recommendation 27

Exercise and physical activity targets should be strived for – if client is unable to achieve these they must start low and build to sustained continuous movement.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 7); majority consensus (90% agreement, 95% CI 6.1 to 7.9)

Recommendation 28

Functional Electrical Stimulation can be incorporated into a programme to improve body composition.

Grade of recommendation: C; Level of agreement: Indecision (Median score of 7); No consensus (40% agreement, 95% CI 5.8 to 7.8)

Medical and Surgical interventions

Medications:

Recommendation 29

Both medical and surgical treatments have important roles to play but must be used in combination with others.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 7.5); Majority consensus (70% agreement, 95% CI 6.3 to 7.9)

Recommendation 30

Counselling and education before commencing anti-obesity medication is necessary.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Majority consensus (90% agreement, 95% CI 6.2 to 8.6)

Recommendation 31

At present orlistat is the only licenced medication for the treatment of obesity. It is associated with increased rates of gastrointestinal events. This could include steatorrhea, fatty faecal incontinence or urgency of bowel movements. The impact of these medications should be considered in the context of bowel management. These effects can be reduced by adhering to a low-fat diet and distributing daily fat intake over three main meals. A multivitamin and mineral supplement may be considered whilst using this medication.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (80% agreement, 95% CI 7.0 to 8.2)

Bariatric surgery

Recommendation 32

When all non-surgical interventions have been tried. Consider for bariatric surgery if BMI ≥35 kg/m^2.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Majority consensus (66.7% agreement, 95% CI 6.7 to 8.1)

Recommendation 33

Consider BMI ≥30 kg/m^2 as cut off for bariatric surgery referral if SCI patients with a significant co-morbidity.

Grade of recommendation: C; Level of agreement: Agreement (Median score of 8); Majority consensus (66.7% agreement, 95% CI 6.7 to 7.9)

Recommendation 34

Symptoms of continuous vomiting, dysphagia, intestinal obstruction or severe abdominal pain require emergency admission under the local surgical team.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Majority consensus (70% agreement, 95% CI 6.0 to 8.5)

Recommendation 35

Patient's medication should be reviewed before and after surgery.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (90% agreement, 95% CI 7.2 to 8.6)

Recommendation 36

Lifelong nutritional supplements are required after bariatric surgery.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Majority consensus (60% agreement, 95% CI 6.3 to 8.3)

Recommendation 37

Lifelong annual blood tests including micronutrient monitoring are required after bariatric surgery.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 7.5); Majority consensus (70% agreement, 95% CI 6.3 to 8.1)

Bowel management

Recommendation 38

Bowel management programmes are multifaceted. Individuals engaging in a weight management programme should be aware that dietary changes to dietary fibre and fluid intake may impact on their bowel management programme.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Strong consensus (100% agreement, 95% CI 7.8 to 8.4)

Recommendation 39

Bowel function should be assessed before and after bariatric surgery. Changes to dietary intake following surgery may have implications for bowel management.

Grade of recommendation: D; Level of agreement: Agreement (Median score of 8); Majority consensus (66.7% agreement, 95% CI 6.9 to 8.5)

1. Development of guidelines on weight management after spinal cord injury

Spinal cord injury (SCI) remains a major health care problem throughout the world (Chhabra *et al.,* 2015). Most patients will require an extended period of hospitalisation following injury and require lifelong follow-up. As life expectancy improves, nutrition related complications such as obesity have increasingly become a concern as it affects activities of daily living and has longer term health implications. Multicomponent interventions are the treatment of choice for the treatment of overweight and obesity in the general population (NICE 2014). Inventions should include behaviour change strategies, advice to increase physical activity levels, improve the quality of the diet, and reduce energy intake. Due to the physiological changes which occur after SCI, the incidence of being overweight and obesity may be under-recognised and subsequently under-estimated. Interventions need to be tailored to the changed nutritional needs and physical activity following a SCI. The focus of this guideline will be to explore these interventions and their use for the treatment and management of overweight and obesity for people with a SCI.

The last two to three decades has seen an increase in the body of literature addressing the diagnosis and treatment of obesity after SCI. However, the number of randomised controlled trials remain limited. The American Dietetic Association (ADA) have produced Evidence-Based Nutrition Practice Guidelines. The focus of these guidelines is on medical nutrition therapy (MNT) for adults with spinal cord injury in the acute care, rehabilitation, and community-dwelling phases of injury. Topics include: evidence for assessment of body composition and nutritional needs, nutrition care to prevent overweight in SCI and physical activity recommendations. (ADA, 2010). These guidelines were developed using hand searches of published literature and searches of electronic databases from PubMed and central from 1966 to 2000.

Since the publication of these guidelines, there have been developments particularly in the area of energy requirements and obesity management. The Multidisciplinary Association of Spinal Cord Injury Professions (MASCIP) in the United Kingdom commissioned a guideline development group in 2014 to review the latest evidence around this topic. An expert panel of clinicians working in the area SCI rehabilitation was formed. Membership included physicians, dietitians,

physiotherapists and psychologists with a background in SCI and weight management. Nurses with expertise in neurogenic bowel management and service users were consulted. Experts in charge of weight management were nominated based on their expertise by the MASCIP. Members from clinical nutrition / dietetics (x4); physiotherapy (x2); clinical and health psychologist (x2); bowel management (x2), medical (x2) and service users (x1) were identified to join the guideline development group.

The present MASCIP guidelines for weight management after SCI used an updated methodology, used by international organisations and recommended for guideline and consensus papers development (Bischoff *et al.,* 2015). The multidisciplinary, multinational membership made recommendations using systematic review, relying on expert opinion only when the systematic approach was not possible or yielded inconclusive results. All members of the working group had declared their individual conflicts of interest according to the rules of the International Committee of Medical Journal Editors (ICMJE).

A systematic literature search was conducted in PubMed, Ovid, Embase, Cinahl, Propero, Centre for Reviews and Dissemination (York), PSYCINFO and the Cochrane Library from 2000 to 2013. If less than 10 papers were found this was extend to 1995-2013. The Panel reviewed the literature using GRADE (Grade of Recommendation, Assessment, Development and Evaluation) methodology (Kavanagh, 2009). The GRADE methodology has previously been validated. It considers the quality of evidence, inconsistency of results, indirectness of evidence, imprecision, reporting bias, the balance between benefits versus harms, and endpoint relevance.

The grade of evidence was determined by several factors, starting with the number and type of research studies (Swiglo *et al.,* 2008):

- A: Highest quality evidence resulted from consistent results or meta-analysis of multiple randomised controlled trials (RCT).
- B: The next highest level was defined by at least one well designed RCT.

- C: Moderate to low level evidence came from controlled trials that were not randomised, cohort- or case-controlled studies, or from multiple time-series trials.
- D: The lowest evidence (very low) was from expert clinical experience or from descriptive studies.

The quality of the evidence was downgraded if there were limitations to the study quality, inconsistencies in findings, imprecise or sparse data, or high likelihood of reporting bias. The grade was increased if there was high consistency of findings or strong evidence of association.

Descriptive findings that did not lead to specific recommendations are grouped in the first part (general considerations), whereas all questions that lead to comparisons of interventions are grouped in a second part (recommendations).

The strength of recommendation was based on a consensus discussion, which included expression and deliberation of expert opinions, risk-benefit ratio of recommendation and a review of supporting evidence, followed by Delphi rounds and votes until agreement was reached. (Table 1)

Following the above methodology, the expert Panel created a series of clinical questions for an adult SCI population, using the Population, Intervention, Comparison and Outcome (PICO) formulation. PCIO questions include a short but exact definition of the population of interest, the intervention, comparators, and outcome. It was anticipated that the data would not permit satisfactory analyses in all cases and that for some questions data would be differently robust for adults and older adults with SCI. It was nonetheless felt appropriate to try to present the data for all age groups in a comparable format. The interpretation of the data from the literature was to be based on the Panel's decision as to the outcomes that matter most to patients, and not necessarily the outcomes presented in the original studies. It was recognised from the outset that some aspects of interventions, such as dietary intervention for obese SCI patients, would not be susceptible for full systematic review, and it was initially intended that the guideline would be constructed in two parts. The first section with the

elements which would necessarily be opinion-based, and a second section considering those elements susceptible to systematic review. The expert panel assessed 221 papers in the systematic review, the data were almost uniformly poor or absent, with studies which were typically small and underpowered. No grade "A" recommendations and a limited number of grade "B" recommendations were possible. Most of the questions for which clinical answers were sought remain unanswered. A final list of 17 PICO-style questions was created (Table 1), which ultimately generated 40 recommendations. (Table 1)

The guideline development group followed the GRADE method to evaluate the quality of evidence and formulate the strength of the recommendations. The methodology is described elsewhere (Kavanagh, 2009). Three meetings were held in the UK (London and Winchester) in addition to a teleconference.

Draft recommendations were made available to interested MASCIP members via an internet platform for comment and online voting (using the Delphi method, Sept 2016 to July 2017). Each recommendation was then rated by all experts on a scale from 1 to 9 (1=disagreement, 9=agreement). A median score was calculated (after exclusion of the highest or lowest ratings, if necessary) that could fall into one of 3 zones: [1-3] = disagreement; [4-6] = indecision; [7-9] = agreement. If the confidence interval of the median was within the first or the last zone, the strength of the recommendation was considered to be weak or strong, respectively. With this methodology, strength of the recommendation has to be distinguished from the level of agreement (or disagreement) obtained from the vote of the experts: for example, it is possible to propose a weak recommendation with a strong agreement, or inversely a strong recommendation with weak agreement. The quality of evidence of each study used to support the recommendations was systematically specified. The global evidence quality was therefore up- or down- modulated by the weight of these three additional factors. When the recommendations received more than 82% agreement in the DELPHI round, they were usually finalised without further discussion. The voting results are indicated for each recommendation according to the above description.

General Recommendations

Introduction

The incidence of obesity is increasing in SCI populations, not only in Europe and North America but worldwide, up to 72.7% of SCI individuals were overweight (Park *et al.*, 2008) and 45% were obese (Wong *et al.*,2012). Many metabolic co-morbidities are associated with obesity; diabetes mellitus and cardiovascular disease are the two most common complications after SCI (Myers *et al.*, 2007).

Obesity causes a high burden of suffering for people with a SCI, their families, and society. For people with a SCI, it leads to increased anxiety, depression and dependency and complicates other co-morbid conditions. For family, it also leads to anxiety, depression and increased time spent caring for a loved one. The annual societal cost of obesity is huge, due to health care and related costs as well as lost wages for patients and family caregivers.

Individuals with SCI are at a higher risk of developing obesity related complications such as diabetes, metabolic syndrome and cardiovascular disease. Dietitians working in SCI rehabilitation should assess the weight and body composition of people with a SCI, adjust energy requirements and implement weight management strategies as appropriate.

1 Classification and Indicies of overweight and obesity in people with SCI

Definition of obesity

Obesity is defined as the excess accumulation of body fat, (more than 25% of body weight for men, and more than 30% for women, (Rush *et al.*,2007) which is well characterised in the general population by body mass index (BMI) due to the high correlation (r= 0.7-0.9) of BMI with fat mass. BMI is measured in kg/m^2 and is calculated by dividing an individual's weight (kg) by his or her height squared (m^2). The World Health Organisation (WHO) has assigned BMI threshold values for the diagnosis of overweight (BMI >25-29.9 kg/m^2) or obese (BMI ≥30 kg/m^2) respectively. (WHO, 2006).

Although BMI is a good obesity screening tool in the general population, its application to individuals with a SCI is problematic as the reductions in lean (muscle) mass and increases in fat mass do not necessarily result in changes in body weight; a key component of the BMI calculation. In addition, measurement of height in

individuals with chronic SCI is neither as feasible nor reproducible. (Buchholz & Bugaresti, 2005; McDonald *et al.,* 2007). Therefore, the BMI thresholds for SCI individuals have been proposed to be lowered to 22 kg/m^2 for overweight and >25 kg/m^2 for obese. (Laughton *et al.,* 2009)

There are limitations in using BMI within the SCI population due to profound changes in fat-free mass (FFM), reflecting obligatory sarcopenia, osteopenia and reduced total body water associated with somatic and autonomic disruption of the spinal cord. Literatures have reported that a BMI of 22-25 kg/m^2 in people with a SCI translates to >30% of body fat, well above the standard cut-off for obesity of 22% body fat in the general population.

Buchholz *et al.,* (2003) recommends that the cut off for obesity should be lowered to 25 kg/m^2. This however came from a study with a low sample size. A larger study (Weaver *et al.,* 2007) used a different BMI level to demonstrate prevalence. The cut off points used were 23-27 Kg/m^2 for overweight and >28 Kg/m^2 for obesity. Neither of these studies identified differences based on level of injury or degree of completeness of paralysis. It has been noted people with paraplegia were found to have a higher prevalence of obesity that those who had tetraplegia. Historically recommendations have been to reduce ideal body weight depending on level of injury (Peiffer *et al.,* 1981). This has meant reducing by 10-15lb for people with paraplegia and 15-20lb for people with tetraplegia. These changes still rely on a measurement of height.

Total fat (adipose) mass and its distribution to visceral rather than subcutaneous tissues is associated with metabolic syndrome and other dangerous medical consequences of obesity. (Gorgery & Gater, 2011) Abdominal obesity, specifically visceral adipose tissue (VAT) increases after SCI. (Edwards *et al.,* 2008) The VAT threshold for obesity has been lowered from 130 cm^2 in general able-bodied (Onat *et al.,* 2010) to 100 cm^2 for people with a SCI. (Inayama *et al.,* 2014)

Waist circumference (WC) is an accurate means of predicting VAT in the able-bodied or general population. Individuals with a WC > 88cm for women and >102 cm for men are defined as obese by the National Institute for Health and Clinical Excellence in the UK (NICE 2014). Although the use of WC as a marker of VAT in individuals with a SCI was debateable (Buccholz & Bugaresti, 2005), newer studies have reported an increase in VAT and obesity related cardiovascular disease risk in a

SCI population; with a disease-specific cut-off for obesity of WC ≥ 94cm. (Eriks-Hoogland *et al.,* 2011; Ravensbergen *et al.,* 2014).

Total body water (TBW), total lean body mass (TLBM), total fat mass (TFM) and extra cellular water (ECW) can be reasonably well predicted by bioelectrical impedance analysis (BIA) in a SCI population. (Buchholz *et al.,* 2003; Crinigliaro *et al.,* 2013).

Dual-Energy X-ray Absorptiometry (DEXA) is another valid and reliable method for estimation of body composition components and reference values have been defined from the National Health and Nutrition Examination Survey (NANES) in general population. Fat mass index (FMI) ≥ 9 kg/m^2 or percentage body fat ≥ 25% for males and ≥ 13 kg/m^2 or percentage body fat ≥35% for females indicates obesity. (Kelly *et al.,* 2009)

Grade of evidence: D

<u>General Considerations:</u>

- Evidence suggests SCI patients have significantly higher fat mass and lower lean body (muscle) mass than persons without SCI.
- The use of an adjusted BMI and waist circumference to classify overweight and obesity, estimate risk for disease and to identify treatment options is recommended.
- Body weight, BMI, and weight circumference should be used to determine the effectiveness of therapy in the reassessment.
- Practitioners should use the BMI to assess overweight / obesity risk. Body weight alone can be used to follow weight loss, and to determine efficacy of therapy.

The Panel recommend for those with an onset of SCI greater than 6 months, a BMI> 25kg/m^2 should be considered at risk of developing obesity related complications. A referral to a dietitian should be considered to those with a BMI >28 kg/m^2 with known metabolic syndromes such as type II diabetes mellitus, dyslipidaemia and hypertension.

1. Evidence suggests SCI patients have significantly higher fat mass and lower lean body (muscle) mass than persons without SCI.
2. We recommend using adjusted BMI and waist circumference to classify overweight and obesity, estimate risk for disease, and to identify treatment options.
3. Body weight, BMI, and waist circumference should be used to determine the effectiveness of therapy in the reassessment.
4. Practitioners should use the BMI to assess overweight / obesity risk. Body weight alone can be used to follow weight loss, and to determine efficacy of therapy.
5. There are limitations with using body mass index (BMI) in SCI population. For those patients with onset of SCI greater than 6 months, a BMI> 25kg/m^2 should be considered at risk of developing obesity related complications. Referral to Dietitian should be considered for those with a BMI >28 kg/m^2 with known metabolic syndromes such as diabetes mellitus, dyslipidaemia and hypertension.
6. Ultrasonography, DEXA, CT and MRI should be used to determine body composition in the research setting.

<u>Recommendations:</u>

- We recommend using an adjusted Body Mass Index (BMI) of 22 kg/m^2 and 25 kg/m^2 to classify overweight and obesity, estimate risk for disease, and to identify treatment options.
- Ultrasonography, Dual-Energy X-ray Absorptiometry (DEXA), Computed tomography (CT) and Magnetic Resonance Imaging (MRI) should be used to determine body composition in a research setting.
- A referral to a dietitian should be considered to those with a BMI >28 kg/m^2 with known metabolic syndromes such as type II diabetes mellitus, dyslipidaemia and hypertension.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see details of the evidence analysis and references, please refer to appendix 1.

2 Education and Weight Management Programmes for people with a SCI

Optimum nutrition is the foundation of good health and key to preventing many of the health-related co-morbidities associated with obesity. The role of nutritional education in prevention and treatment of overweight and obesity in people with a SCI was explored.

Weight management strategies in terms of planning and design of a weight management programme were also examined. This included aspects such as duration of the programme and realistic weight loss targets.

2.1: Nutrition education in the prevention and treatment of overweight and obesity.

Two studies were identified that relate to weight management therapy programmes for people with a spinal cord injury in the literature. Chen *et al.,* 2006 relates to a study of 16 people with SCI who attended a 12-week weight management programme. Radomski *et al.,* (2011) also a 12-week education and exercise programme for which 13 adults with SCI attended.

Chen *et al.,* (2006) quoted a weight reduction of 3.5 ± 3.1Kg (3.8% of initial weight) at week 12 (p=0.0004). They then followed patients up for a further 12 weeks after completion of the study. At week 24 they quote a 2.9 ± 3.7kg (3.0% of initial weight) loss (P=0.01). This would indicate that the weight loss was sustained, and weight regain limited weight after the 12-week programme had been completed.

Radomski *et al.,* (2011) demonstrated a weight reduction of 5.4 kg (5.6% of initial weight) at week 12 (p=0.13). They had planned to follow patients up at week 24 but they were lost to follow up and therefore figures were not presented. They also had data at week 12 for 10 patients rather than the original 13 patients that were successfully recruited.

Both studies included an element of exercise and activity into the programme as essential components in encouraging a negative energy balance. Whilst both studies show promising results, sample size remained low. Radomski *et al.,* 2011 reported problems with recruitment. Both studies also discussed the practical issues associated with weekly weight management programmes when travel is required.

Chen *et al.,* (2006) was able to report data for people 12 weeks after completion of the programme. Only 13 patients were available for follow up. 6 patients had continued to lose weight but at a slower rate (2.1 ±1.8kg), 4 had remained constant and

3 had put on weight (3.0 ±2.2kg). This would indicate that without the programme patients were unable to maintain the level of weight reduction seen whilst the support was continuing.

Grade of evidence: C

General Considerations:

- There is level C evidence (from two observational studies Chen *et al.*, 2006; Radomski *et al.*,2011) that a 12-week exercise and weight management programme can produce weight loss in individuals with SCI. Long term weight management was not confirmed after the session stopped.
- There was no published evidence of the success of preventative education on weight management.
- Nutrition education should be individualised and included as part of patient's education in SCI centres. Studies from the general population suggest nutrition education covering food labels, recipe modification, cooking classes can increase knowledge and may lead to improved food choices.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see details of the evidence analysis and references, please refer to appendix 1.

2.2: Weight Management Programmes to Prevent or Treat Overweight / Obesity in people with SCI.

Two studies (Chen *et al.*, 2006, Radomski *et al.*, 2011) examined a multi-disciplinary approach to weight management in treating overweight individuals. Both were successful in achieving improvements in body weight in their cohort.

No studies were identified that examined prevention.

Grade of evidence: C

General Considerations:

- Evidence would suggest a multidisciplinary approach to managing weight loss is effective at reducing weight in spinal cord injured patients and should include a physical activity programme.
- Weight loss and weight maintenance therapy should be based on a comprehensive weight management programme including diet, physical therapy and behaviour therapy. The combination approach is more successful than using any one intervention alone.
- The combination of a reduced calorie diet and increased physical activity is recommended as it produces weight loss that may also result in reduced abdominal adipose tissue and increase in cardiorespiratory fitness.

Recommendations:

- Weight loss and weight maintenance therapy should include a combination of calorie reduction of 600-800kcal/day, increased physical activity, and behaviour therapy.
- The combination of a reduced calorie diet and increased physical activity is recommended as it produces weight loss. It may also result in reduced abdominal adiposity
- The combination of a reduced calorie diet and increased physical activity is recommended as it produces weight loss. It may also result in reduced abdominal adiposity

Supporting evidence.

These recommendations were created from the evidence analysis on the above questions. To see details of the evidence analysis and references, please refer to appendix 1.

2.3: Optimal Length of a Weight Management Programmes (including frequency of contact with a health care professional)

There was no specific evidence relating to on the optimal length of weight management programmes for people with a SCI. Two studies investigating weight management programmes (Chen *et al.,* 2006 & Radomski *et al.,* 2011) were both 12-week

programmes. Both programmes were weekly sessions and included both diet and exercise elements. It was noted by both that the distance to travel to the programmes was an inhibitory factor.

Grade of evidence: C

General Considerations:

- Two observational studies (Chen *et al.*, 2006; Radomski *et al.*, 2011) found that a 12-week exercise and weight management programme can produce weight loss in individuals with SCI.
- There was no evidence available on the outcomes of individual weight management consultations (one-to-one sessions) for people with a SCI.
- Weight loss and weight maintenance programmes which provide a higher frequency of contacts between the patient and the clinician and provide long term support should be considered whenever possible. This can lead to more successful weight loss and weight maintenance.
- Dietetic therapy should last at least 6 months.

Recommendations:

- Weight management programmes should be of at least 6 months duration or until weight loss goals are achieved. A weight maintenance programme should be implementation afterwards.
- A greater frequency of contacts between the patients and practitioner may lead to more successful weight loss and weight maintenance.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see details of the evidence analysis and references, please refer to appendix 1.

2.4: Weight Loss Goals:

There were no specific evidence relating to weight goals in weight management programmes for people with a spinal cord injury. The evidence that is available is

related to altered body composition. There is no evidenced consensus on ideal body weights following spinal cord injury.

It is known that spinal cord injury results in altered body composition due to a reduction of muscle and bone mass. This then influences metabolic rate (Rajan *et al.*, 2008). As previously discussed, BMI requires that both weight and height are known. The difficulty for people with a SCI is obtaining an accurate height measurement. Spungen *et al.,* (2003) demonstrated that spinal cord injury patients had 13% increased fat mass compared to people without a SCI. This opens the argument that there should be a reduction in the recommended BMI for differentiating between normal, overweight and obesity in spinal cord injury.

Grade of evidence C

<u>General Considerations:</u>

- There were no specific evidence relating to weight goals in weight management programmes for people with a spinal cord injury.
- Weight loss goal should be individualised as part of weight loss program.
- People with SCI who attended a well-designed weight management programme can achieve a weight loss of as much as 3-5% of initial body weight over 6 months.
- Recommendations for the general population are that weight loss rate should be 0.5 to 1 kg per week for the first 6 months.
- Initial weight loss goal should be to reduce body weight by 10% from initial body weight, further weight loss can be attempted if indicated through further assessment.
- Weight loss rate should be 0.5 to 1 kg per week for the first 6 months. Weight loss can plateau and intervention may need to be reviewed.

<u>Recommendations:</u>

- Weight loss goals should be individualised as part of weight loss program.
- Weight loss rate should be 0.5 to 1 kg per week for the first 6 months and should aim to achieve an initial weight loss goal of up to 10% from initial body weight.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see details of the evidence analysis and references, please refer to appendix 1.

3.0: Dietary Interventions

Achieving energy balance remains the cornerstone of weight control. Dietary interventions for weight management explored two aspects – estimating energy needs and the dietary approaches which may be used to achieve weight loss.

3.1: Energy Expenditure

Following spinal cord injury physiological and metabolic adaptations will affect energy requirements. The focus of this question was to look at resting metabolic rate after spinal cord injury and determine the most appropriate predictive equations to use to estimate calorie requirements.

Resting Metabolic Rate/Predictive Equations:

The resting metabolic rate (RMR) or resting energy expenditure (REE) is important because it forms a large part of the total energy an individual expends. Most research refers to RMR rather than Basal Metabolic Rate (BMR) as the requirements to achieve the latter are very exacting. Predictive equations are used to estimate an individual's energy requirement and from that, one can calculate a calorie intake that will lead to weight loss.

Six relevant studies were identified from the literature search. In total, there were 135 patients with paraplegia and 51 with tetraplegia. 31 were female 155 males. Bauman *et al.,* (2004) and Bucholz *et al.,* (2003), looked at RMR in people with a SCI compared to those without a SCI. Their studies indicated that RMR in people with SCI tends to be significantly lower. 95% of people in their studies had paraplegia. The reduction in RMR in people with SCI compared to those without varied from 9% to 12%.

The reason for the reduction in RMR in people with SCI compared to people without may be due to a reduction in Fat Free Mass (FFM). FFM and RMR were

correlated in Bauman *et al.,* 2004 and Bucholz *et al.,* (2003), studies, although Yilmaz *et al.,* (2007) reported there were no significant relationship between FFM and Basal Metabolic Rate (BMR). Yilmaz concluded that autonomic dysreflexia may have some effect on BMR but that there was no evidence for an effect from spasticity. Further studies were needed.

There is considerable variation in the RMR of people with SCI. Standard deviation from measured RMR in the Bauman twins study (Bauman *et al.*,.,, 2004) found there were significantly less than those of the able-bodied co-twins (mean, sd: 1387 268 vs. 1660 324 kcal/d, $p < 0.005$, and 1682 388 vs. 1854 376 kcal/d, $p < 0.05$, respectively) Bauman *et al.,(*2004) and Bucholz *et al.,*(2003), found RMR was 14-27% lower in persons with spinal cord injury versus those without, which were similar to the values for their controls. Collins *et al.,* 2010 did not find a significant difference between RMR in people with tetraplegia compared to those with paraplegia (No p value given). Perret *et al.,* 2011 found significant difference was shown between RMR in acute and chronic SCI injury.

Predictive equations may overestimate RMR in people with spinal cord injury. Bucholz *et al.,* (2003), looked at this and the Schofield equation overestimated RMR by 5.5%. ($p<0.01$). Bauman *et al.,* 2004 in fact found that the measured REE was 3% higher than predicted by the Harris Benedict equation though no p Value was stated.
Grade of evidence C

<u>General Considerations:</u>

- RMR appears to be lower in people with SCI than the people without SCI. It would be helpful if people with SCI were aware of this so that they can tailor their intake accordingly.
- There is considerable variation in the RMR of people with SCI.
- Estimate energy requirement should be based on RMR. If possible, RMR should be measured (e.g. by indirect calorimetry). To use predictive equation to estimate RMR when RMR cannot be measured.
- No evidence currently to suggest that any one of predictive equations is superior to the others.

- If RMR cannot be measured, then the Oxford- Henry or Miffin St Joer equations should be used. Actual weight is the recommended equations for estimating RMR for overweight / obese individuals with SCI.

Equations for estimating basal metabolic rate from gender, age and weight (Henry, 2005)

Male

Age	Kcal/ day
18-30	16.0W + 545
30-60	14.2W + 593
60-70	13.0W + 567
70+	13.7W + 481

Female

Age	Kcal/ day
18-30	13.1W + 558
30-60	9.74W + 694
60-70	10.2W + 572
70+	10.0W + 577

W = weight in kilograms

Equations for estimating basal metabolic rate from gender, age and weight and height (Henry, 2005)

Men	
18-30 years	14.4 x weight (kg) + 313 x height (m) + 113
30-60 years	11.4 x weight (kg) + 541 x height (m) – 137
>60 years	11.4 x weight (kg) + 541 x height (m) - 256
Women	
18-30 years	10.4 x weight (kg) + 615 x height (m) -282

30-60 years	8.18 x weight (kg) + 502 x height (m) – 11.6
>60 years	8.52 x weight (kg) + 421 x height (m) + 10.7

Mifflin-St Jeor Equations (Mifflin *et al.*, 1990)

Men: RMR= (9.99 x weight in kg) + (6.25 x height in cm) – (4.92 x age) +5

Women: RMR= (9.99 x weight in kg) + (6.25 x height in cm) – (4.92 x age) -161

RMR= Resting Metabolic Rate

Recommendations:

- Predictive equations may overestimate Resting Metabolic Rate (RMR) in people with SCI. These need to be used with caution until an appropriate predictive equation can be found.
- There was no evidence from this review to suggest a particular predictive equation was more accurate than another.
- RMR appears to be lower in people with a SCI than the non-SCI population. Healthcare professionals should be made aware of this so that they can tailor their recommendations accordingly
- Where possible, RMR should be measured using indirect calorimetry.

Supporting evidence.

These recommendations were created from the evidence analysis on the above questions. To see details of the evidence analysis and references, please refer to appendix 1.

Dietary Approaches

The efficacy and long-term sustainability of a variety of dietary approaches to weight control were explored. These included implementing a calorie deficit, using a 600-calorie reduction, altering the macronutrients composition (Low Glycaemic Index (GI), Low Fat, and High Protein), the use of commercial programmes and the use of meal replacements.

3.2: Calorie Deficit

There is limited research available on the effectiveness of calorie reduction alone in achieving weight loss in the management of overweight and obesity in people with spinal cord injury.

Three papers emerged from the literature search and all three were initial studies that could be a starting point for large scale studies.

They were single group uncontrolled trials that ran over 12 to 24 weeks. Chen *et al.,* (2006) study had 16 participants, Radomski *et al.,* 2011 had 13 participants whilst Wong *et al.,* (2011) had 19. In all three studies subjects were advised on nutrition, exercise and behaviour modification over the course of 12 weeks and they achieved significant weight loss of 3.8%, 5.6% and 3.5% respectively in that time. Chen *et al.,* (2006) found 88% of subjects lost weight over the initial 12 weeks but only 46% of subjects were continuing to lose weight at the 24 week follow up. These studies used weight reduction/healthy eating plans. Chen *et al.,* 2006 adapted the 'Time- Calorie Displacement Diet' for people with SCI, emphasizing the importance of protein and nutrients related to skin integrity and bowel, bone and bladder health. Weight loss was achieved through calorie reduction by reducing energy dense foods (meats, cheeses, sugars and fats) and increasing foods high in fibre (fruit and vegetables and wholegrains). Radomski *et al.,* (2011) stated the diet was individualised and based on the Take Action Programme for Weight Management. This is a 12 program for weight loss that combines nutrition, physical activity and motivational coaching. No details were available on the dietary aspects of this programme. Wong *et al.,* (2011) discussed general healthy eating dietary advice based on the eat-well plate and personalised goals were set.

Chen *et al.,* (2006) did monitor subjects' food intake via food recall questionnaires and these showed an increase in fibre and reduction in calories though not reaching significance. Food recall questionnaires are flawed in that they rely on people's memory for their accuracy. Radomski *et al.,* 2011 did not identify methods for assessing dietary compliance. It was therefore difficult to determine if the recommended diet was followed. Wong *et al.,* (2011) agreed individual diet, activity or behavioural targets with client.

Due to the lack of studies, small numbers of subjects involved and the lack of control groups in the three papers it is difficult to draw definitive conclusions regarding the role of calorie reduction in achieving weight loss in people who are overweight or obese with a SCI.

Grade of evidence: C

General Considerations:

- These small studies suggest that dietary approaches used in the people without SCI can be used for people with SCI.
- A diet that is higher in fibre and has fewer energy dense foods may be helpful in reducing weight
- Samples sizes are relatively small with limited follow up and therefore further studies are required.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

3.3: Portion control or a 600-calorie deficit approach

Diets that have a 600 kcal/day deficit (that is, they contain 600 kcal less than the person needs to stay the same weight) in combination with expert support and intensive follow-up, are recommended for sustainable weight loss (NICE, 2014). One of the ways that this can be achieved is by translating estimated energy requirements into practical food portions or servings sizes from the various food groups and incorporating national healthy eating guidelines. (BDA, 2007) The UK's and Ireland food-based guidelines use the "Eatwell Guide" (Public Health England, 2016) or "Food Pyramid" (Department of Health, 2016) as a policy tool used to define government recommendations on achieving a healthy balanced diet.

Two single uncontrolled multicomponent trials were identified. This included dietary intervention, physical activity and behavioural strategies. This made it difficult to ascertain the impact of diet on weight loss.

Wong *et al.,* (2011) demonstrated an average weight loss of 3.7 kg (3.5%). Body weight and triceps skin fold thickness were significantly reduced whilst mid upper arm muscle circumference increased. The dietary intervention used healthy eating guidelines and behavioural change techniques in line with the NICE Guidelines. (NICE, 2014) Strategies employed included the "Eatwell plate". The "Eatwell plate"

model (recently renamed the "Eatwell Guide") is a visual representation of the types and proportions of foods needed for a healthy balanced diet (Public Health England, 2016). Individualised plans and were also provided as appropriate and dietary patterns and intake were reviewed periodically.

Chen *et al.*, (2006) achieved an average weight loss of 3.5kg weight loss (3.8%). There was a significant reduction in BMI, waist circumference, and skin fold thickness. Dietary recommendations started at 1400 kcal diet for men and 1200 kcal diet for women. The diet strategy used was the Time Calorie Displacement Approach to Weight Control. As previously described his approach is based on the concept of energy density. Using this approach an initial calorie level is prescribed with a prescribed number of servings from each of the 5 food groups: fats and oils, meat and dairy, starches, fruit and vegetables. Emphasis is placed on the ingestion of larger quantities of high bulk low energy density foods (vegetables, fruit, high fibre grains and cereals) and the moderation of high energy density foods (meats, cheeses, sugars and fats). Consideration was given to appropriate protein and nutrients for skin health, bowel function and bone health. A list of the preferred foods that provided more fibre and less energy was provided. Easy, healthier meal preparation advice was also provided.

Two small single controlled studies suggest that a manipulation of the diet to conform to current healthy eating guidelines and or controlled calorie intake does achieve weight loss in combination with an exercise programme underpinned by behaviour change techniques. They also demonstrate that weight loss is possible without compromising lean body mass. However, these studies are limited in their statistical significance and the absence of a control group.

Grade of evidence C

<u>General Considerations</u>

- Guidance on appropriate portions of foods at meals and snacks may result in reduced energy intake and weight loss.
- Manipulation of the diet to conform to healthy eating guidelines or using a calorie controlled high bulk low energy approach does achieve modest weight loss as part of an exercise and behaviour programme.

- Using the "Eatwell plate" model (recently renamed as the "Eatwell Guide") in combination with individualised plans can achieve weight loss in addition to physical activity and behavioural strategies recommendations.
- General population guidance (NICE, 2014) recommend diets have a 600 kcal/day deficit or a calorie reduction by lowering the fat content (low-fat diets), in combination with expert support and intensive follow up, for sustainable weight loss.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

3.4: Meal replacements and Very Low-Calorie Diets

There were no studies identified exploring the use of meal replacements (MR) or very low-calorie diets (VLCD) in the treatment of overweight and obesity in people with a SCI.

A position statement by the Dietitians Working in Obesity Management (DOM UK) (BDA, 2007.) considers MRs as: portion-controlled products fortified with vitamin and minerals. They can be used to replace one or two meals in the day allowing one low calorie meal using standard foods [and snacks]. This approach provides an energy intake in the region of 1200-1600kcal/day. They are available in liquid, powder or snack bar form. DOM UK supports the use of MRs, as one of a range of dietary treatment options which may be employed as part of a comprehensive weight management programme delivered by appropriately qualified health care professionals. They may be a useful strategy for individuals who have difficulty with food selection, finding time to prepare meals or struggle to control or understand portion sizes. They advocate their use in conjunction with dietary education and support.

VLCDs, (also known as very low energy diets or VLCDs) are a formula food specially prepared to supply a minimum amount of carbohydrates and the daily requirements of the essential nutrients. The UK NICE Guidelines (NICE 2014) defines very-low-calorie diets as 800 kcal/day or less. The European Food Safety Authority (EFSA, 2015) have issued a directive regarding composition of total dietary replacement for weight control. They recommended the minimum energy content of

total diet replacements for weight control can be derived from the minimum macronutrient content of such diets. They proposed that:

> a minimum protein content based on a Population Reference Intake for protein adjusted for the overweight or obese (75 g/day), a minimum carbohydrate content based on the obligatory glucose demands of the brain (30 g/day) and minimum contents of linoleic acid (11 g/day), α-linolenic acid (1.4 g/day) and micronutrients based on reference values established either by the Panel or by other scientific or authoritative bodies. Derived from the minimum content of macronutrients, the Panel proposed a minimum energy content of total diet replacements for weight control of 2 510 kJ/day (600 kcal/day). The Panel also advised on potential conditions and restrictions of use for these products (EFSA, 2015).

The UK NICE Guidelines recommends:

- Consider low-calorie diets (800–1600 kcal/day) but be aware these are less likely to be nutritionally complete.
- Do not routinely use very-low-calorie diets (800 kcal/day or less) to manage obesity (defined as BMI over 30kg/m^2). Only consider very-low-calorie diets as part of a multicomponent weight management strategy, for people who are obese and who have a clinically-assessed need to rapidly lose weight (for example, people who need joint replacement surgery or who are seeking fertility services).
- The diet is nutritionally complete.
- The diet is followed for a maximum of 12 weeks (continuously or intermittently)
- The person following the diet is given ongoing clinical support.

Before starting someone on a very-low-calorie diet as part of a multicomponent weight management strategy:

- Consider counselling and assess for eating disorders or other psychopathology to discuss the risks and benefits with them.
- Tell them that this is not a long-term weight management strategy, and that regaining weight may happen and is not because of their own or their clinician's failure.

- Discuss the reintroduction of food following a liquid diet with them.
- Provide a long-term multicomponent strategy to help the person maintain their weight after the use of a very-low-calorie diet. People should be encouraged to eat a balanced diet in the long term, consistent with other healthy eating advice. (NICE, 2014)

Evidence Grade D

<u>General Considerations:</u>

- No studies were identified which examined the effectiveness of meal replacement diets or very low-calorie diets to achieve weight loss in the treatment of overweight and obesity in people with a SCI.
- In the general population, MRs may offer an additional dietary treatment strategy to achieve weight loss. They may be suitable for people who have difficulty with appropriate food selection and /or portion control. Meal replacements such as liquid meals, meal bars, and calorie-controlled packaged meals may be used a part of the dietary component of a comprehensive weight management programme. Substituting one or two daily meals or snacks with meal replacement is a successful weight loss and weight maintenance strategy. They should be used in conjunction with nutritional education and support. Nutritional adequacy of the diet should be assessed and monitored.
- NICE (NICE, 2014) guidelines do not recommend the routine use of very-low-calorie diets (800 kcal/day or less) to manage obesity. They should only be considered as part of a multicomponent weight management strategy, for people who are obese and who have a clinically-assessed need to rapidly lose weight and for a defined period of time. Weight maintenance strategies should be discussed on completion of a VLCD. A healthy balance diet should be advised long term.

Supporting evidence

These recommendations were created from the evidence analysis on the above. To see detail of the evidence analysis and references, please refer to appendix 1.

3.5 Altering the Macronutrient Content of the Diet (low glycaemic index, low carbohydrate or high protein) to achieve weight loss.

There are currently no studies available to explore the effectiveness of specific dietary macronutrient manipulation to achieve weight loss for the management of overweight and obesity in people with a SCI**.**

In the UK and Ireland food-based guidelines for the public reflect recommendations for how much and which types of foods to eat for good health. Dietary Reference Values (DRV) are a series of estimates of the energy and nutritional requirements of different groups of healthy people in the population. DRVs have been set for the general population. They are not recommendations or goals for individuals. DRVs for total fat, saturated fat, total carbohydrates and sugars are given as a percentage of daily energy intake for adults. Current UK recommendations for the population are that total fat is not more than 35%, total carbohydrate 50% and 30g fibre. (SACN 2015, COMA 1991) In Ireland the recommendation for the population are that total fat is between 20-35%, total carbohydrate 45-65% and ≥ 25g of fibre. (Food Safety Authority of Ireland, 2011).

The main requirement of a dietary approach to weight loss is that total energy intake should be less than energy expenditure. Dietary guidelines for altering the macronutrient content of the diet require an individualised approach from an appropriately trained professional. The UK NICE Guidelines recommendation that:

- Tailor dietary changes to food preferences and allow for a flexible and individual approach to reducing calorie intake.
- Do not use unduly restrictive and nutritionally unbalanced diets, because they are ineffective in the long term and can be harmful.
- Encourage people to improve their diet even if they do not lose weight, because there can be other health benefits (NICE, 2014).

Recent clinical guidelines produced for health practitioners who provide advice on weight management for New Zealand adults advised that

> Low-energy, very low-energy, low glycaemic index and modified macronutrient diets, coupled with nutrition advice, can all achieve similar weight losses of about 4 kg over 12 months, although weight loss depends on the individual, and may range from weight maintenance to weight losses of over 10 kg (Ministry of Health New Zealand, 2017).

A healthy balance diet reflecting public reflect recommendations should be advised long term.

Grade of evidence: D

General Considerations.

- There are currently no studies available to explore the effectiveness of specific dietary macronutrient manipulation to achieve weight loss in the management of overweight and obesity in people with a SCI.
- A range of macronutrient modifications, which incorporate calorie-restriction can support clinically significant weight loss in overweight and obese adults in the general population. Dietary modification should be cognizant of the impact of a spinal cord injury on health, co-morbidities, nutritional requirements, income and be responsive to changes in health. A healthy balance diet should be advised long term.

Supporting evidence

These recommendations were created from the evidence analysis on the above. To see detail of the evidence analysis and references, please refer to appendix 1.

3.5 Commercial Dietary Approaches (such as Weight Watchers, Slimming World or diet supplements)

There are currently no studies available to explore the effectiveness of commercial programmes or products for the management of overweight and obesity in people with a SCI. There are many commercial weight management options available including but not limited to Weight Watcher and Slimming World. In general, these programmes are delivered by non-clinically trained staff, offer frequent contact, and may use dietary restriction in combination with promotion of increased physical activity to achieve weight loss

NICE (NICE, 2014) recommends:

Multicomponent interventions are the treatment of choice.

Ensure weight management programmes include behaviour change strategies to increase people's physical activity levels or decrease inactivity, improve eating behaviour and the quality of the person's diet, and reduce energy intake.

When choosing treatments, consider:

- the person's individual preference and social circumstance and the experience and outcome of previous treatments (including whether there were any barriers)
- the person's level of risk, based on BMI and, where appropriate, waist circumference and any comorbidities.

The guideline also recommends that any healthcare professionals who deliver interventions for weight management have the relevant competencies and have had specific training in the area. Generic weight management programmes may not be aware of the unique physical implications of SCI.

Due to limited product information weight loss supplement these would not be recommended until the evidence of their safety, efficacy and cost effectiveness have been independently investigated.

Grade of evidence: D

<u>General Considerations:</u>

- There are currently no studies available to explore the effectiveness of commercial programmes or products for the management of overweight and obesity in people with a SCI.
- Further research is required to determine what role commercial weight management programmes can provide to achieve weight loss for people with a spinal cord injury.
- NICE Guidelines (NICE, 2004), recommends multicomponent interventions incorporating behaviour change strategies, physical activity recommendations and changes to eating diet quality and calorie reduction. They should be sensitive to the person's individual social circumstance and medical conditions (such as comorbidities) and be delivered by appropriately qualified personnel.

<u>Recommendations:</u>

- The main requirement of a dietary approach to weight loss is that total energy intake should be less than energy expenditure. Consideration to differences in physical activity levels, energy requirements, bowel management programme needs and any co-morbidities people with a spinal cord injury may have.

- Research is limited regarding dietary approaches to weight loss for people with a SCI. NICE guideline recommends that diets that have a 600 kcal/day deficit (that is, they contain 600 kcal less than the person needs to stay the same weight) in addition to expert support and intensive follow-up for sustainable weight loss.
- Recommendations on appropriate portion sizes of food groups as part of a calorie-controlled diet can be a useful strategy to use as part of a comprehensive weight management programme.
- Total caloric intake should be distributed throughout the day. This should include a healthy breakfast as part of regular balanced meals.
- Consider low-calorie diets (800–1600 kcal/day) but be aware these are less likely to be nutritionally complete.
- Meal replacements can be another dietary treatment strategy to consider as part of a comprehensive weight management programme. They may be suitable for people who have difficulty with appropriate food selection and /or portion control. They should be used in conjunction with nutritional education and support.
- Do not routinely use very-low-calorie diets VLCD (800 kcal/day or less) to manage obesity. They should only be considered as part of a multicomponent weight management strategy. Weight maintenance strategies should be discussed on completion of a VLCD. A healthy balance diet should be advised long term.

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

3.6 Meal Frequency and weight loss

No studies specific to people with a spinal cord injury and weight reduction were identified. Neither papers (Chen *et al.*, 2006 or Radomski *et al.*, 2011) included details of meal frequency in their studies. In the absence of evidence, it seems prudent to advise people with a SCI to follow advice recommended widely for the people without SCI

from such professional bodies as the Academy of Nutrition and Dietetics. (Raynor *et al.,* 2016)

Grade of evidence: D

General Considerations:

- For weight loss and weight maintenance, the registered dietitian should individualise the meal pattern to distribute calories at meals and snacks throughout the day, including breakfast

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

4: Behavioural Therapy / Psychological Intervention

Behavioural therapy in addition to diet and physical activity leads to additional weight loss in the general population. There is no specific evidence that describes the effectiveness of behavioural therapy in weight management programme for SCI patients. If resources allowed, a comprehensive weight management program should make use of multiple strategies for behaviour therapy including self-monitoring, stress management, stimulus control, problem solving, contingency management, cognitive restructuring and social support.

Research examining the efficacy of psychological and behavioural treatments for people who are over-weight following a Spinal Cord Injury (SCI) is extremely limited. A search of the literature revealed just two papers that met inclusion criteria for the review.

The paper by van der Woude *et al.,* (2013) describes the research protocol for the Active Lifestyle Rehabilitation Interventions in aging Spinal Cord injury (ALLRISC) multi centre research programme and therefore does not offer any evidence regarding the efficacy of psychological interventions.

Chen and colleagues (Chen *et al.,* 2006) conducted a non-controlled study to examine the effectiveness of a 12-week multi-component intervention for weight loss with a cohort of 16 individuals with SCI (15 traumatic, 1 spina bifida) who were either classed as over-weight or obese. The intervention programme utilised time-calorie

displacement diet and involved 12 weekly classes that aimed to increase knowledge of the impact of nutrition and exercise on weight reduction, facilitate change in health behaviours, and enhance social support. The latter half of the programme included physical exercise sessions, as well as sessions designed to educate participants about the relationship between emotions and eating behaviour, and stress management. The results show that 14 of 16 participants lost weight over the 12-week programme, with an average weight loss of 3.8% of initial body weight. Participants' BMI significantly reduced, as did waist circumference, neck circumference, and skinfold thickness. Body fat was also found to significantly decrease, with no significant change found to lean mass or bone mineral content. The study also found that measures of the subjective sense of ability to control weight, eating habits, knowledge of nutrition, quality of diet, and psychosocial and physical functioning also significantly improved. Information available at 12-week post-intervention follow up for 13 participants indicated that the weight of 10 people was below baseline, with an average weight loss in this group of 3%, and BMI, total fat mass, and waist circumference all being significantly decreased. Participants also reported improvements in activities of daily living and body image. There are several limitations to this study, including a lack of control/comparison group, as well as a selective sample of individuals with a relatively high level of educational attainment, individuals with a relatively close proximity to the study centre, all but one participant having an SCI due to trauma, and participants being of a relatively young age. Finally, the nature of the study methodology means that it is not possible to examine which ingredients of the intervention were active in helping participants reduce weight, and/or which elements impacted on improvements made in psychological wellbeing. It is therefore not possible to infer what psychological processes and/or interventions were most helpful.

Grade of Evidence: C/D

<u>General Considerations</u>

- There are a very limited number of research studies that have examined psychological interventions for weight loss specifically in individuals with SCI, with no controlled research having been conducted.

- There is evidence that multicomponent interventions that include nutritional and psychological components alongside physical activity can help individuals with SCI to lose weight, with improvements maintained at follow up.
- Such programmes may also have a positive impact on activities of daily living (ADLs), psychosocial and physical functioning, and body image.
- It is not possible to draw inferences regarding the active psychological ingredient in weight loss interventions for people with SCI due to limitations in study design.
- Unclear whether intervention would be helpful for individuals with non-traumatic injury, individuals with multiple physical co-morbidities, or individuals who did not live close to clinic.
- Effectiveness of behavioural therapy for long-term weight maintenance has been shown in the absence of long-term follow up data

<u>Recommendations</u>

- Behavioural therapy, in combination with a caloric deficit diet, provides additional benefits in assisting patients to lose weight short term.
- No one behavioural technique appeared to be superior to any other in its effect on weight loss

Supporting evidence

These recommendations were created from the evidence analysis on the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

5. Physical Activity Interventions

Inpatient Exercise programmes

Various exercise interventions were looked at in the literature. These included: leisure time physical activity of moderate intensity e.g. hand cycling or swimming for > 25 mins per day which was beneficial for waist circumference measurements (Bucholz *et al.*,2012), a combination of sports (Basketball, swimming, table tennis, canoeing) and daily physiotherapy as part of a supervised in-patient programme of between 700 – 800 minutes per week combined was effective at improving body weight and composition

in paraplegic patients and only lean body mass in tetraplegic patients (Neto and Lopez 2011)

Grade of evidence: C

General Consideration:

- The low quality of these studies does not give us a definitive prescription of exercise that promotes weight loss, but it is apparent that for tetraplegic groups measuring body composition rather than body weight may be more sensitive to changes brought about by exercise.

Recommendations:

- In-patient exercise programmes should include a variety of sports as well as physiotherapy to create exposure to different ways of exercising.

Physical Activity levels

Evidence found concurred with current world health organisation guidance on physical activity levels stating that persons with spinal cord injury (C5 and below) who achieved 150 minutes of physical activity within a week were more likely to have lower fat mass/body fat percentage (Tanhoffer *et al.*, 2014 and D'Oliviera *et al.*, 2014). Only Tanhoffer *et al.*, 2014 found a reduction in body weight and waist circumference and included various sports including weight lifting, FES, circuit training, swimming, hand cycling, wheelchair tennis, wheelchair rugby.

Akbar *et al.*, (2015) demonstrated a reduction in BMI in persons that took part in regular basketball sessions (at least 1-2 sessions per week). Bucholz *et al.*, (2012) recognized the importance of overcoming sedentary behaviours and the necessity to increase frequency and intensity and/or duration of physical activity. This paper suggests that to overcome sedentary behaviour of being a wheelchair user alone, persons should be wheeling continuously each day for a minimum of 27 minutes.

Grade of evidence: C

General Considerations

- Persons with spinal cord injury should be aiming to engage in exercise or physical activity for at least 150 minutes spread over a week. This can

include exercise/sport/ Personal Activities of Daily Living (PADL)/ Domestic Activities of Daily Living (DADL).

- People with a spinal cord injury should be encouraged to maintain daily levels of moderate activity as part of leisure time for at least 25 minutes a
- For persons that are unable to achieve the above levels they should start low and gradually increasing in time/frequency and duration should be part of an ongoing rehabilitation program.
- For persons that are unable to achieve the above levels starting low and gradually increasing in time/frequency and duration should be part of an ongoing rehabilitation program
- The Evidence does not highlight any one exercise or PAL that is better than anything else therefore when starting at very low levels anything that allows an individual to move continuously for a sustained period of time is a good starting point.

<u>Recommendations</u>

- In-patient exercise programmes should include a variety of sports as well as physiotherapy to create exposure to different ways of exercising.
- Physical activity or exercise should aim to be 150 minutes per week spread over the week.
- People with a SCI should be also encouraged to incorporate 25 minutes of leisure time physical activity per day as part of a healthy lifestyle.
- Exercise and physical activity targets should be strived for – if client is unable to achieve they must start low and build to sustained continuous movement.

Electrical stimulation

No FES cycle ergometry intervention demonstrated a reduction in weight (Skold *et al.*, 2002, Lui *et al.*,2007). Across all FES modalities, in all but one of the papers all studies demonstrated an improvement with thigh cross sectional area or lean body mass, indicating that FES/NMES may have a positive influence on body composition. Interventions included FES with body weight support treadmill training (Carvalho *et al.*,2008, Giangregorio *et al.*, 2012), cycle ergometary (Skold *et al.*, 2002, Griffin *et al.*,

2009, Lui *et al.*,2007) and neuromuscular electrical stimulation with or without resistance (Ryan *et al.*, 2013, Carty *et al.*,2013, Clark *et al.*,2007

Use of Partial Weight bearing Treadmill training (PWBTT) (Carvalho *et al.*, 2008 and Giangregorio *et al.*, 2012) can lead to improvements in cross sectional areas of the thigh, although this was only significant in the Carvalho study after 12 months.

Grade of evidence: C

General Considerations

- FES could be considered as an option in weight loss program to improve body composition to assist with weight management.
- FES in conjunction with cycling, direct stimulation or treadmill training can lead to improvement in body composition by increasing muscle mass in the thigh. Improvement in muscle mass can help to raise energy expenditure levels.

Recommendation:

- Functional Electrical Stimulation can be incorporated into a programme to improve body composition.

Telehealth

One study (Rimmer *et al.*, 2013) explored a telehealth weight management programme for spinal cord injured patients and found that physical activity advice, regular coaching and dietary advice provided via telephone is effective at reducing weight in people with an incomplete spinal cord injury that are predominantly wheelchair users i.e. >50% of the time

Grade of evidence: B

General Considerations:

- Telehealth coaching is viable for weight loss in spinal injury population and it should aim to provide the participant with a personalised physical activity programme, regular coaching and dietary advice for optimum results.

Recommendation:

- Telehealth can be used to provide a person with a personalised physical activity programme, dietary advice and regular coaching.

Supporting evidence

These recommendations were created from the evidence analysis on above questions. To see detail of the evidence analysis and references, please refer to appendix 1

6.0 Medical Management of Obesity

6.1 Pharmacological Interventions

Risk factors associated with obesity tend to be more prevalent in people with SCI such as lipid disorders, metabolic syndrome and diabetes. (Bauman *et al.*, 1999; Lee *et al.*, 2005) Overweight or obese people with a SCI should be screened for major chronic conditions associated with obesity such as type 2 diabetes mellitus, cardiovascular disease, hypertension, hyperlipidaemia and obstructive sleep apnoea. Secondary causes of obesity should also be considered. Medications used in the treatment of other conditions can exacerbate weight gain. For example, many antidepressants and antipsychotic medications are associated with weight gain e.g. mirtazapine or lithium. Weight losing, or weight neutral medication should therefore be considered where possible.

For those who continue to have difficulty losing weight, anti-obesity medications may offer an adjunctive therapy as part of a comprehensive weight management programme. At present there is no reported evidence reporting the efficacy of anti-obesity medication in people with a SCI. Therefore, guidance is taken from recommendations for the general population. (NICE, 2014) Dietitians working in SCI rehabilitation should liaise with members of multi-disciplinary team regarding the use of licenced anti-obesity medications for people who meet the NICE criteria (NICE, 2014) i.e. a BMI of 28 kg/m^2 or more with associated risk factors or a BMI of 30 kg/m^2 or more. Orlistat therapy should only be continued beyond 3 months if the person has lost at least 5% of their initial body weight since starting drug treatment. The decision to use drug treatment for longer than 12 months (usually for weight maintenance) should be discussed in terms of benefits and limitations.

At present Orlistat is the only licensed medication used as an adjunct treatment of overweight and obesity. The dose is 60-120mg three time per day. Orlistat inhibits gastrointestinal lipases, promoting fat malabsorption diet (>30 % of calories from fat), resulting in a caloric deficit. A low-fat diet is encouraged, and daily intake of fat should be distributed over three main meals. Taking orlistat with a meal very high in fat increases the possibility of gastrointestinal adverse reactions (SIGN 2010). Orlistat

should only be used where diet, physical activity and behavioural changes are supported. Those taking the medication need to be aware of lifestyle changes required as side effects include decreased absorption of fat soluble vitamins, steatorrhea, oily spotting, flatulence with discharge, faecal urgency, oily evacuation, increased defaecation and faecal incontinence. These factors are of importance in the context of bowel management for people with a SCI.

NICE Guidelines would recommend (in Adults):

- Consider pharmacological treatment only after dietary, exercise and behavioral approaches have been started and evaluated.
- Consider drug treatment for people who have not reached their target weight loss or have reached a plateau on dietary, activity and behavioral changes.
- Make the decision to start drug treatments after discussing the potential benefits and limitations with the person, including the mode of action, adverse effects and monitoring requirements, and the potential impact on the person's motivation. Make arrangements for appropriate healthcare professionals to offer information, support and counselling on additional diet, physical activity and behavioural strategies when drug treatment is prescribed. Provide information on patient support programs.
- Pharmacological treatment may be used to maintain weight loss rather than to continue to lose weight.
- If there is concern about micronutrient intake adequacy, a supplement providing the reference nutrient intake for all vitamins and minerals should be considered, particularly for vulnerable groups such as older people and young people.
- Offer support to help maintain weight loss to people whose drug treatment is being withdrawn; if they did not reach their target weight, their self-confidence and belief in their ability to make changes may be low.
- Monitor the effect of drug treatment and reinforce lifestyle advice and adherence through regular review.
- Consider withdrawing drug treatment in people who have not reached weight loss targets (NICE, 2014)

Grade of Evidence: D

General Considerations:

- There is no reported evidence reporting the efficacy of anti-obesity medication in people with a SCI. Recommendations from the general population are advised.

Recommendations:

- Counselling and education before commencing anti-obesity medication is necessary.
- Orlistat are associated with increased rates of gastrointestinal events. This could include steatorrhea, fatty faecal incontinence or urgency of bowel movements. This impact of these medications should be considered in the context of bowel management. These effects can be reduced by adhering to a low-fat diet and distributing daily fat intake over three main meals. A multivitamin and mineral supplement may be considered whilst using this medication.

Supporting evidence

These recommendations were created from the evidence analysis on the following questions. To see detail of the evidence analysis and references, please refer to appendix 1.

6.2: Bariatric surgery

Recent figures from the UK National Bariatric Surgery Registry (NBSR) reported 18,283 bariatric procedure were performed in the UK and Ireland during 2011 to 2013 (Wellbourn *et al.,* 2014). Roux-en-Y Gastric Bypass (RYGB) remains the most common operation performed, flowed by Laparoscopic Adjustable Gastric Banding (LAGB) and Laparoscopic sleeve gastrectomy (LSG) (9,526, 4,705, 3,797 procedures, respectively). These figures show a sharp rise in the number of bariatric procedures being carried out in the UK and Ireland compared to the first report published in 2010. Indeed, these numbers are only going to rise, given the good safety profile of bariatric surgery that was demonstrated in the 2014 NBSR report, the rising trend of obesity in the UK and the fact that surgery is currently the most effective and sustainable method of weight loss for the treatment of morbid obesity (Sjöström *et al.,* 2007)

Obese individuals tend to consume food that is either unhealthy or of poor nutritional value; contains high levels of fat, salt and / or sugar; and frequently lacks proteins, vitamins, minerals and fibre. (Kaidar-Person *et al.*, 2008a; Kaidar-Person *et al.*, 2008b) Up to 80% of bariatric surgery individuals often describe as having "high-calorie malnutrition", a state of excess caloric intake with concurrent nutritional deficiencies that results in inadequate ability to utilise these calories effectively. The toxic by-products of incomplete biochemical reactions create a vicious cycle resulting in further weight gain, depression, eating disorders, metabolic syndrome, fatigue and other nutritional related complications. (NICE, 2014). All bariatric procedures affect nutritional intake and absorption to various degrees, they will not necessarily result in a nutritionally improved diet. (Sarwer *et al.*, 2008) Therefore, lifelong supplementation of vitamins, minerals and trace elements is recommended to ensure a well-balanced diet for individuals after bariatric surgery. Is well known that severe deficiencies in several micronutrients, e.g. folic acid, vitamin B12, vitamin D, iron and folic acid are common after bariatric surgery.

Five reports of the use of surgery for the management of obesity in people with a SCI were identified. No studies with evidence higher than a grade C were found from which guidance could be formulated on the use of surgery for overweight/obesity management in people with a SCI.

Complications of bariatric surgery reported in people with a SCI were infrequent but included early post-operative chest infections requiring intravenous antibiotics, laparoscopy for internal hernia repair at 3 months, peptic ulcer disease requiring proton pump inhibitors, gastro-jejunal anastamotic strictures requiring balloon dilatation. Reference was made in the case reports/series to bowel difficulties and vitamin deficiencies, but neither were reported.

The most recent Cochrane review (Colquitt *et al.*,2014) of the surgical management of obesity in the general population, published in 2014, concludes that surgical management achieves greater weight loss, improved co-morbidities and some small gains in quality of life, compared with non-surgical management when followed up at 1-2 years; Laparoscopic Roux-en-Y by-pass and laparoscopic sleeve gastrectomy achieved greater weight loss & BMI reduction at 5years, than laparoscopic adjustable gastric banding.

Bilio-pancreatic diversion with duodenal switch resulted in greater weight loss and BMI reduction than Laparoscopic Roux-en-Y by-pass in the morbidly obese but carried a higher re-operation rate.

NICE guidance from 2014 recommends that in the general population, patients are referred for surgery if they fulfill these criteria:

- Bariatric surgery can result in a substantial weight loss, and therefore it is an available option for well-informed and motivated patients with a BMI ≥40 kg/m^2 or ≥35 kg/m^2 with nutrition related co-morbidities and acceptable operative risks.
- BMI of 40kg/m^2 or greater OR BMI between 35kg/m^2 and 40kg/m^2 with a significant co-morbidity e.g. type 2 diabetes.
- Bariatric surgery is an option for carefully selected SCI patients with clinically severe obese when all non-surgical measures have been tried but the patient has not achieved or maintained adequate weight loss.
- Patient has received/will receive intensive management in a SCI centre with access to a multidisciplinary team including a physician with a special interest, specialist nurse, specialist dietitian, psychologist or psychiatrist, physiotherapist or physical activity specialist.
- Patient is fit for surgery and anesthesia
- Patient is committed to long-term follow-up for at least 2 years. (NICE, 2014)

The choice of surgical procedure depends on:

- Degree of obesity
- Co-morbidities
- Facilities and equipment available
- Experience of the person performing the operation

Patients require at least 2 years' post-operative follow-up in the bariatric service.

Grade of evidence: C

<u>General Considerations.</u>

- Regarding referral for surgery of obese SCI patients, we suggest adherence to the NICE recommendations but in line with the altered classification of overweight and obese for the SCI population, referral for surgery should occur once BMI reaches 35kg/m^2 (morbid obesity) or if BMI is between 30kg/m^2 & 35kg/m^2 with a significant co-morbidity.

- A randomized controlled trial is needed, comparing the use of bariatric surgery with non-surgical methods for obesity management in SCI patients; ideally follow-up needs to be carried out over a minimum of 5 years. A range of surgical methods also need to be studied. In addition to measuring of BMI, body fat, other anthropometrics and biochemical analysis, consideration should also be given to assessing measures of activity, participation, quality of life and self-reported health measures.

Recommendations:

- When all non-surgical interventions have been tried. Consider for bariatric surgery if BMI $\geq$35 kg/m^2.
- Consider BMI $\geq$30 kg/m^2 as cut off for bariatric surgery referral for SCI patients with a significant co-morbidity.
- Symptoms of continuous vomiting, dysphagia, intestinal obstruction or severe abdominal pain require emergency admission under the local surgical team.
- Patient's medication should be reviewed before and after surgery.
- Lifelong nutritional supplements are required after bariatric surgery.
- Lifelong annual blood tests including micronutrient monitoring are required after bariatric surgery.

Supporting evidence

These recommendations were created from the evidence analysis of the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

7.0 Neurogenic Bowel Management

Neurogenic bowel management is multifaceted and an important consideration for people with SCI. People with a SCI will experience either upper motor neuron (reflex) bowel or lower motor neuron (areflexic) bowel. Each type of neurogenic bowel dysfunction may require different adjustments to dietary fibre and fluid intake. Previous guidelines (MASCIP, 2012) have highlighted the complex interplay of many factors such as medication, exercise, diet, fibre and fluid on bowel management. Anti-obesity

medications, bariatric surgery or dietary changes used in the management of obesity may have implications for bowel management in people with SCI.

No studies were identified which addressed directly the effect of medication or bariatric surgery on bowel management. However, two studies did acknowledge the potential for surgery and diet to impact on bowel management.

Chen *et al.*, (2006) conducted a weight loss programme employing diet, exercise and behaviour modification in people with a SCI. The diet strategy used the "Time Calorie Displacement Approach to Weight Control", The dietary composition places emphasis on the ingestion of large quantities of high bulk, low energy density foods (vegetables, fruit, high fibre grains and cereals) and in moderation high energy density foods (meats, cheeses, sugars and fats). Food frequency questionnaires showed a significant reduction in saturated fat and an increase in fibre intake. Whilst not statistically significant, time required for bowel movements seemed to improve.

The Academy of Nutrition and Dietetics (ADA, 2009) recommends a Registered Dietitian (RD) should monitor at regular intervals the fibre intake of persons with spinal cord injury and neurogenic bowel, and the amount of dietary fibre provided should be adjusted as necessary. Provision of excessive fibre may result in unacceptable flatulence, significant increase in stool volume and painful abdominal distension, while provision of inadequate fibre may result in constipation or bowel impaction. In addition to fibre intake fluid should also be considered. Caution is advised in both calculations as predictive equations tend to overestimate fluid needs in those who are overweight or obese. Recommendations for fluid intake should also be considered in the context of bladder management. Further research is needed to establish fluid requirements.

Wong *et al.*, (2013) in a single case study acknowledges the importance of assessing bowel function pre- and postoperatively and the impact surgery may have on neurogenic bowel dysfunction management. Following surgery, dietary guidelines may result in changes to dietary fibre intake. The potential impact of these changes on bowel management should be discussed with member of the multidisciplinary team such as the nurse and dietitian.

Grade of Evidence: D

<u>General Considerations:</u>

- There is limited research addressing the impact of diet and bariatric surgery on bowel management in people with a spinal cord injury.

- The impact of interventions may have on dietary fibre intake and potentially bowel management should be discussed with member of the multidisciplinary team such as the nurse and dietitian or surgeon
- In one study in people with a SCI, the diet component of a weight management programme was based on high bulk, low energy density foods (vegetables, fruit, high fibre grains and cereals) and in moderation high energy density foods (meats, cheeses, sugars and fats). This diet found a trend towards a reduced time required for the passing of bowel motions.
- Constipation or diarrhoea can be a side effect of using a VLCD in the general population. This should be discussed with the multidisciplinary team prior to commencing a VLCD so that bowel management can be evaluated accordingly.
- Dietary guidelines will differ depending on the bariatric surgical procedure involved. Changes to dietary fibre and food intake will have implications on bowel management. This should be discussed with the nurse and dietitian to prevent constipation. In general, mineral and vitamin supplementation will be required and should be taken as directed.

<u>Recommendations:</u>

- Bowel management programmes are multifaceted. Individuals engaging in a weight management programme should be aware that dietary changes to dietary fibre and fluid intake may impact on their bowel management programme.
- Bowel function should be assessed before and after bariatric surgery. Changes to dietary intake following surgery may have implications for bowel management.

Supporting evidence

These recommendations were created from the evidence analysis of the above questions. To see detail of the evidence analysis and references, please refer to appendix 1.

Conclusions

Most of the studies selected for inclusion in this guideline were low to moderate in terms of methodological quality, one of the most effective weight reduction and BMI

correction was produced by bariatric surgery, follow by a combination of diet and physical activity. We did not find any published evidence to suggest anti-obesity medication could reduce weight in obese SCI individuals. Due to the link between obesity and metabolic syndromes and all-cause mortality. Weight management after SCI is a legitimate therapeutic target. Based on feasibility and associated risk, trial of diet and physical activity / exercise therapy is recommended prior to bariatric surgery. Further trial on the efficacy (effectiveness and safety) of anti-obesity medication in obese SCI patients is warranted.

Contributions

SW, LOC, AT, CT, RL, GM, ES, AG, LMD, NW, SH

Systematic Review Protocol Development:
SW, LOC, AT, CT, GM, LMDM, SH, CW

Data Collection and Analysis
SW, LOC, AT, CT, RL, GM, ES, AG, NW, SH, CF, AM, AG

Guideline Preparation:
SW, LOC, AT, CT, RL, GM, ES, AG, NW, SH

Guideline Revision
SW, LOC, AT, CT, RL, GM, ES, AG, NW, SH, LMDM, LC, EW

Acknowledgements:

The systematic review and grading of evidence were performed by an expert Panel with help from member's institution. The authors would like to thank Lorena Cascant, Sarah Lewis, Steve O'Driscoll, Mel Williams, Angela Wickls, Alison Lyons, Chris Wilson, Liz Croxan, Eva Wallace, Cliona Fennelly, Amy Meegan, and Amanda Gerrard.

We are most thankful to the City University London for hosting live meetings for the group.

Conflict of interest: Parts of the study proposal were submitted to present at the International Spinal Cord Society annual conference in September 2016.

Table 1: Research questions used to formulate PICO statements

Q1	Classify overweight and obesity be classified in adults with a SCI
Q2:	How can body composition be measured in adults with a SCI?
Q3:	Is nutrition education effective in the treatment or prevention of overweight and obesity in adults with a SCI
Q4:	What weight management strategies are available to prevent or treat overweight / obesity in hospital and community settings?
Q5:	What is the optimal length of weight management therapy (including frequency of contact)?
Q6:	What is a realistic weight loss goal for adults with a SCI?
Q7:	What resting metabolic rate calculation or predictive equations can be?
Q8:	What reduced calorie diets can be used to achieve weight loss in people with a SCI?
Q9:	Is eating/ meal frequency an effective strategy in weight management in people with a SCI?

Q10: Is portion control an effective strategy in weight management in people with a SCI

Q11: Are meal replacements an effective strategy in weight management in people with a SCI?

Q12: What is the evidence for altered macronutrient content of diets (low glycemic index, low carbohydrate or high protein) or commercial weight management programs or products (such as weight watchers, sliming world or commercial products such as XLS Medical) in the treatment of overweight and obesity for people with a SCI?

Q13: What types of physical activity are effective in achieving weight loss in people with a SCI?

Q14: What psychological or behavioral strategies are effective in improving quality of life in obese people with a SCI?

Q15: What anti-obesity medications are effective in achieving weight loss in people with a SCI?

Q16: Is bariatric surgery are effective treatment for weight loss in people with a SCI?

Q17: Bowel management: what are the implication of the above treatments for bowel management?

References

Akbar, M., Brunner, M., Ewerbeck, V., Wiedenhöfer, B., Grieser, T., Bruckner, T., Loew, M. and Raiss, P. (2015) Do overhead sports increase risk for rotator cuff tears in wheelchair users? *Archives of physical medicine and rehabilitation*, *96*(3), pp.484-488

American Dietetic Association, 2010. Spinal Cord Injury (SCI) Evidence-Based Nutrition Practice Guideline 2009.

Bauman, W.A., Adkins, R.H., Spungen, A.M. and Waters, R.L. (1999) The effect of residual neurological deficit on oral glucose tolerance in persons with chronic spinal cord injury. *Spinal cord*, *37*(11), p.765.

Bauman, W.A., Spungen, A.M., Wang, J. and Pierson Jr, R.N. (2004) The relationship between energy expenditure and lean tissue in monozygotic twins discordant for spinal cord injury. *Journal of rehabilitation research and development*, *41*(1), p.1

Bischoff, S.C., Singer, P., Koller, M., Barazzoni, R., Cederholm, T. and van Gossum, A. (2015) Standard operating procedures for ESPEN guidelines and consensus papers. Clinical Nutrition, 34(6), pp.1043-1051.

British Dietetic Association. (2007) Dietitians in Obesity Management UK. Position Paper. Dietetic Weight Management Intervention for Adults in a One-to-One setting: Is it Time for a Radical Rethink? The British Dietetic Association,

British Nutrition Foundation, 2017. Nutrition Requirements. https://www.nutrition.org.uk/attachments/article/907/Nutrition%20Requirements_Revised%20Oct%202017.pdf [accessed 24th April 2018]

Buchholz, A.C. and 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*(9), p.513.

Buchholz, A.C. and Pencharz, P.B. (2004) Energy expenditure in chronic spinal cord injury. *Current Opinion in Clinical Nutrition & Metabolic Care*, *7*(6), pp.635-639.

Buchholz, A.C., Horrocks, J., Martin Ginis, K.A., Bray, S.R., Craven, B.C., Hicks, A.L., Hayes, K.C., Latimer, A.E., McColl, M.A., Potter, P.J. and Smith, K. (2012) Changes in traditional chronic disease risk factors over time and their relationship with leisure-time physical activity in people living with spinal cord injury. *Applied Physiology, Nutrition, and Metabolism*, *37*(6), pp.1072-1079

Buchholz, A.C., McGillivray, C.F. and Pencharz, P.B. (2003) Differences in resting metabolic rate between paraplegic and able-bodied subjects are explained by differences in body composition. *The American journal of clinical nutrition*, 77(2), pp.371-378.

Buchholz, A.C., McGillivray, C.F. and Pencharz, P.B. (2003) The use of bioelectric impedance analysis to measure fluid compartments in subjects with chronic paraplegia1. *Archives of physical medicine and rehabilitation*, *84*(6), pp.854-861.

Carty, A., Coughlan, G., Crowe, L. and Pt, B.C. (2011) Alterations in Body Composition and Spasticity Following Neuromuscular Electrical Stimulation Training in Spinal Cord Injury. *Topics in Spinal Cord Injury Rehabilitation*, *16*(1), p.36.

Chen Y, Henson S, Jackson AB, Richards JS. Obesity intervention in persons with spinal cord injury. *Spinal Cord*. 2006; 44: 82-91.

Chhabra, H.S., (2015). ISCOS textbook on Comprehensive Management of Spinal Cord Injuries. *ISBN-13*, pp.978-93.

Cirnigliaro, C.M., La Fountaine, M.F., Emmons, R., Kirshblum, S.C., Asselin, P., Spungen, A.M. and Bauman, W.A. (2013) Prediction of limb lean tissue mass from bioimpedance spectroscopy in persons with chronic spinal cord injury. *The journal of spinal cord medicine*, *36*(5), pp.443-453.

Clark, J.M., Jelbart, M., Rischbieth, H., Strayer, J., Chatterton, B., Schultz, C. and Marshall, R. (2007) Physiological effects of lower extremity functional electrical stimulation in early spinal cord injury: lack of efficacy to prevent bone loss. *Spinal Cord*, *45*(1), p.78.

Collins, E.G., Gater, D., Kiratli, J., Butler, J., Hanson, K. and Langbein, W.E. (2010) Energy cost of physical activities in persons with spinal cord injury. *Medicine and science in sports and exercise*, *42*(4), pp.691-700.

Colquitt, J.L., Pickett, K., Loveman, E. and Frampton, G.K. (2014) Surgery for weight loss in adults. *The Cochrane Library*

D'Oliveira, G.L.C., Figueiredo, F.A., Passos, M.C.F., Chain, A., Bezerra, F.F. and Koury, J.C. (2014) Physical exercise is associated with better fat mass distribution and lower insulin resistance in spinal cord injured individuals. *The journal of spinal cord medicine*, *37*(1), pp.79-84.

Department of Health (1991) Report on Health and Social Subjects 41 Dietary Reference Values (DRVs) for Food Energy and Nutrients for the UK, Report of the Panel on DRVs of the Committee on Medical Aspects of Food Policy (COMA) 1991. The Stationary Office. London

Department of Health, Ireland. (2016) "Healthy Food for Life – the Healthy Eating Guidelines and Food Pyramid". https://www.healthpromotion.ie/hp-files/docs/HPM00796.pdf. [accessed 24th April 2018]

Edwards, L.A., Bugaresti, J.M. and Buchholz, A.C. (2008) Visceral adipose tissue and the ratio of visceral to subcutaneous adipose tissue are greater in adults with than in those without spinal cord injury, despite matching waist circumferences–. *The American journal of clinical nutrition*, *87*(3), pp.600-607.

EFSA NDA Panel (EFSA Panel on Dietetic Products, Nutrition and Allergies). (2015) Scientific Opinion on the essential composition of total diet replacements for weight control. *EFSA Journal* 2015;13 (1):3957, 52 pp. doi:10.2903/j.efsa.2015.3957 [accessed 23rd April 2018].

Eriks-Hoogland, I., Hilfiker, R., Baumberger, M., Balk, S., Stucki, G. and Perret, C. (2011) Clinical assessment of obesity in persons with spinal cord injury: validity of waist circumference, body mass index, and anthropometric index. *The journal of spinal cord medicine*, *34*(4), pp.416-422.

Food Safety Authority of Ireland. (2011). Scientific Recommendations for Healthy Eating Guidelines in Ireland. Food Safety Authority of Ireland https://www.fsai.ie/recommendationsforhealthyeatingguidelinesinireland.html [accessed 30th August 2017]

Giangregorio, L., Catharine, C., Richards, K., Kapadia, N., Hitzig, S.L., Masani, K. and Popovic, M.R. (2012) A randomized trial of functional electrical stimulation for walking in incomplete spinal cord injury: effects on body composition. *The journal of spinal cord medicine*, *35*(5), pp.351-360.

Gorgey, A.S. and Gater, D.R. (2011) A preliminary report on the effects of the level of spinal cord injury on the association between central adiposity and metabolic profile. *PM&R*, *3*(5), pp.440-446.

Griffin, L., Decker, M.J., Hwang, J.Y., Wang, B., Kitchen, K., Ding, Z. and Ivy, J.L. (2009) Functional electrical stimulation cycling improves body composition, metabolic and neural factors in persons with spinal cord injury. *Journal of Electromyography and Kinesiology*, *19*(4), pp.614-622.

Henry CJK. (2005) Basal metabolic rate studies in humans: measurement and development of new equations *Public Health Nutrition*: 8(7A), 1133–1152.

Inayama, T., Higuchi, Y., Tsunoda, N., Uchiyama, H. and Sakuma, H. (2014) Associations between abdominal visceral fat and surrogate measures of obesity in Japanese men with spinal cord injury. *Spinal Cord*, *52*(11), p.836.

Kaidar-Person, O., Person, B., Szomstein, S. and Rosenthal, R.J. (2008) Nutritional deficiencies in morbidly obese patients: a new form of malnutrition? *Obesity surgery*, *18*(7), pp.870-876.

Kavanagh BP. (2009) The GRADE system for rating clinical guidelines. *PLoS Med*; **6**: e10000094.

Kelly, T.L., Wilson, K.E. and Heymsfield, S.B. (2009) Dual energy X-Ray absorptiometry body composition reference values from NHANES. *PloS one*, *4*(9), p. e7038.

Laughton, G.E., Buchholz, A.C., Ginis, K.M. and Goy, R.E. (2009) Lowering body mass index cutoffs better identifies obese persons with spinal cord injury. Spinal cord, 47(10), p.757.

Lee, M., Myers, J., Hayes, A., Madan, S., Froelicher, V.F., Perkash, I. and Kiratli, B.J. (2005) C-reactive protein, metabolic syndrome, and insulin resistance in individuals with spinal cord injury. *The journal of spinal cord medicine*, *28*(1), pp.20-25.

Liu, C.W., Chen, S.C., Chen, C.H., Chen, T.W., Chen, J.J.J., Lin, C.S. and Huang, M.H., (2007) Effects of functional electrical stimulation on peak torque and body composition in patients with incomplete spinal cord injury. *The Kaohsiung journal of medical sciences*, *23*(5), pp.232-240.

MASCIP. (2012) Guidelines for management of neurogenic bowel dysfunction in individuals with central neurological conditions. *Initiated by the Multidisciplinary Association of Spinal Cord*, pp.1-60.

McDonald, C.M., Abresch-Meyer, A.L., Dopier Nelson, M. and M. Widman, L.M. (2007) Body mass index and body composition measures by dual x-ray absorptiometry in patients aged 10 to 21 years with spinal cord injury. *The journal of spinal cord medicine*, 30(sup1), pp. S97-S104.

Mifflin, M.D., St Jeor, S.T., Hill, L.A., Scott, B.J., Daugherty, S.A. and Koh, Y.O., (1990) A new predictive equation for resting energy expenditure in healthy individuals. *The American journal of clinical nutrition*, *51*(2), pp.241-247.

Ministry of Health. (2017) Clinical guidelines for weight management in New Zealand adults. Wellington: Ministry of Health. https://www.health.govt.nz/system/files/documents/publications/clinical-guidelines-for-weight-management-in-new-zealand-adultsv2.pdf [accessed 31st March 2018]

Myers, J., Lee, M. and Kiratli, J. (2007) Cardiovascular disease in spinal cord injury: an overview of prevalence, risk, evaluation, and management. *American journal of physical medicine & rehabilitation*, *86*(2), pp.142-152.

National Institute for Clinical Excellence (NICE), 2014. Obesity: the prevention, identification, assessment and management of overweight and obesity in adults and children. CG189 [accessed 31st March 2018].

Neto, F.R. and Lopes, G.H. (2011) Body composition modifications in people with chronic spinal cord injury after supervised physical activity. *The journal of spinal cord medicine*, *34*(6), pp.586-593.

Onat, A., Uğur, M., Can, G., Yüksel, H. and Hergenç, G. (2010) Visceral adipose tissue and body fat mass: predictive values for and role of gender in cardiometabolic risk among Turks. *Nutrition*, *26*(4), pp.382-389.

Park, P., Upadhyaya, C., Garton, H.J. and Foley, K.T. (2008) the impact of minimally invasive spine surgery on perioperative complications in overweight or obese patients. *Neurosurgery*, *62*(3), pp.693-699.

Perret, C. and Stoffel-Kurt, N. (2011) Comparison of nutritional intake between individuals with acute and chronic spinal cord injury. *The journal of spinal cord medicine*, *34*(6), pp.569-575.

Public Health England. (2016) The Eatwell Guide. Available from: https://www.gov.uk/government/publications/the-eatwell-guide [accessed 24th April 2018]

Radomski, M., Finkelstein, M., Hagel, S., Masemer, S., Theis, J. and Thompson, M. (2011) A pilot wellness and weight management program for individuals with spinal cord injury: Participants' goals and outcomes. *Topics in Spinal Cord Injury Rehabilitation*, *17*(2), pp.59-69.

Rajan, S., McNeely, M.J., Warms, C. and Goldstein, B. (2008) Clinical assessment and management of obesity in individuals with spinal cord injury: a review. *The journal of spinal cord medicine*, *31*(4), pp.361-372.

Ravensbergen, H.R.J.C., Lear, S.A. and Claydon, V.E. (2014) Waist circumference is the best index for obesity-related cardiovascular disease risk in individuals with spinal cord injury. *Journal of neurotrauma*, 31(3), pp.292-300.

Raynor, H.A. and Champagne, C.M. (2016) Position of the Academy of Nutrition and Dietetics: interventions for the treatment of overweight and obesity in adults. *Journal of the Academy of Nutrition and Dietetics*, *116*(1), pp.129-147.

Rimmer, J.H., Wang, E., Pellegrini, C.A., Lullo, C. and Gerber, B.S. (2013) Telehealth weight management intervention for adults with physical disabilities: a randomized controlled trial. *American journal of physical medicine & rehabilitation*, *92*(12), pp.1084-1094

Rush, E.C., Goedecke, J.H., Jennings, C., Micklesfield, L., Dugas, L., Lambert, E.V. and Plank, L.D. (2007) BMI, fat and muscle differences in urban women of five ethnicities from two countries. *International Journal of Obesity*, *31*(8), p.1232.

Ryan, T.E., Brizendine, J.T., Backus, D. and McCully, K.K. (2013) Electrically induced resistance training in individuals with motor complete spinal cord injury. *Archives of physical medicine and rehabilitation*, *94*(11), pp.2166-2173.

Sarwer, D.B., Wadden, T.A., Moore, R.H., Baker, A.W., Gibbons, L.M., Raper, S.E. and Williams, N.N. (2008) Preoperative eating behaviour, postoperative dietary adherence, and weight loss after gastric bypass surgery. *Surgery for Obesity and Related Diseases*, *4*(5), pp.640-646.

Scientific Advisory Committee on Nutrition (SACN). (2015) Carbohydrates and Health Report. Public Health England.

Scottish Intercollegiate Guidelines Network. Management of obesity: a national clinical Guideline. Edinburgh. 2010 http://www.sign.ac.uk/assets/sign115.pdf [accessed 31st March 2018]

Sjöström, L., Narbro, K., Sjöström, C.D., Karason, K., Larsson, B., Wedel, H., Lystig, T., Sullivan, M., Bouchard, C., Carlsson, B. and Bengtsson, C. (2007) Effects of bariatric surgery on mortality in Swedish obese subjects. *New England journal of medicine*, *357*(8), pp.741-752.

Skold C, LoÈnn L, Harms-Ringdahl K, Hultling C, Levi R, Nash M, and Seiger A. (2002) Effects of functional electrical stimulation training for six months on body composition and spasticity in motor complete tetraplegic spinal cord-injured individuals. *Journal of Rehabilitation Medicine*, *34*, pp.25-32.

Spungen, A.M., Adkins, R.H., Stewart, C.A., Wang, J., Pierson Jr, R.N., Waters, R.L. and Bauman, W.A. (2003) Factors influencing body composition in persons with spinal cord injury: a cross-sectional study. *Journal of applied physiology*, *95*(6), pp.2398-2407.

Swiglo, B.A., Murad, M.H., Schunemann, H.J., Kunz, R., Vigersky, R.A., Guyatt, G.H. and Montori, V.M. (2008). A case for clarity, consistency, and helpfulness: state-of-the-art clinical practice guidelines in endocrinology using the grading of recommendations, assessment, development, and evaluation system. *The Journal of Clinical Endocrinology & Metabolism*, *93*(3), pp.666-673.

Tanhoffer, R.A., Tanhoffer, A.I., Raymond, J., Hills, A.P. and Davis, G.M. (2014) Exercise, energy expenditure, and body composition in people with spinal cord injury. *Journal of Physical Activity and Health*, *11*(7), pp.1393-1400.

Van der Woude, L.H.V., de Groot, S., Postema, K., Bussmann, J.B.J., Janssen, T.W.J., ALLRISC and Post, M.W.M. (2013) Active Lifestyle Rehabilitation interventions in aging spinal cord injury (ALLRISC): a multicentre research program.

Weaver, F.M., Collins, E.G., Kurichi, J., Miskevics, S., Smith, B., Rajan, S. and Gater, D. (2007) Prevalence of obesity and high blood pressure in veterans with spinal cord injuries and disorders: a retrospective review. *American journal of physical medicine & rehabilitation*, *86*(1), pp.22-29.

Welbourn, R., Small, P., Finlay, I., Sareela, A., Somers, S., Mahawar, K., Walton, P. and Kinsman, R. (2010) The United Kingdom National Bariatric Surgery Registry.

Second Registry Report 2014. NBSR, London. http://www.bomss.org.uk/wp-content/uploads/2014/04/Extract_from_the_NBSR_2014_Report.pdf [accessed 31 March 2018]

Wong, S., Barnes, T., Coggrave, M., Forbes, A., Pounds-Cornish, E., Appleton, S. and Belci, M. (2013) Morbid obesity after spinal cord injury: an ailment not to be treated?. *European journal of clinical nutrition*, *67*(9), p.998.

Wong, S., Derry, F., Jamous, A., Hirani, S.P., Grimble, G. and Forbes, A. (2012) The prevalence of malnutrition in spinal cord injuries patients: a UK multicentre study. *British Journal of Nutrition*, *108*(5), pp.918-923.

Wong, S., Graham, A., Grimble, G. and Forbes, A. (2011) Spinal clinic for obese out-patient project (SCOOP)—a 1-year report. *Food and Nutrition Sciences*, *2*(08), p.901.

World Health Organisation (WHO) (2006) Global Database on Body Mass Index. http://apps.who.int/bmi/index.jsp [Accessed 03 May 2015]

Yilmaz, B., Yasar, E., Goktepe, S., Alaca, R., Yazicioglu, K., Dal, U. and Mohur, H. (2007) Basal metabolic rate and autonomic nervous system dysfunction in men with spinal cord injury. *Obesity*, *15*(11), pp.2683-2687.