Efficacy of Strength Training on Fatigue and Performance in Patients with Multiple Sclerosis: A Systematic Review

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Abstract

Background: Multiple sclerosis is a chronic debilitating condition, which can cause muscle weakness and fatigue. Exercise has often been thought of as contraindicated in Multiple Sclerosis (MS) sufferers. It is only recently been documented that there may actually be benefits to partaking in physical exercise. *Objective*: To determine the effect strength training has on fatigue and performance in patients with MS. *Methods*: A systematic review of the literature was conducted. *Results*: The review found positive evidence for the implementation of strength training to improve function and fatigue in patients with MS. *Conclusion*: Strong evidence exists for the use of exercise to treat MS symptoms, specific protocols and additional research looking at more disabling forms of MS are necessary to ensure the patient receives the best management.

Key Words: Multiple Sclerosis, Strength Training, Fatigue, and Resistance Training.

Background

Multiple Sclerosis (MS) is a chronic neurological autoimmune disorder, affecting the central nervous system (CNS), also known as demyelination disease due to the destruction of the nerves myelin sheath. MS is a complex and heterogeneous disease, with no known etiology (Dalgas 2011 and De Souza et al 2011). This disease has been recorded as one of the leading causes of neurological disability in young adults, affecting approximately

2.5million worldwide (Hartung 2011), females have been found to be twice as likely to develop MS than men (Dalgas 2011 and Ronai 2011) and the disease is typically diagnosed in the 2nd to 4th decade of life (Dalgas 2011).

Five main types of MS have been recorded within the literature, each with distinct characteristics and definitions (Table 1). The main symptoms attributed with MS are weakness, poor balance, fatigue, lack of co-ordination, and heat intolerance (Dalgas 2011 and Mulcare and Jackson 2006).

Type	Incidence %	Characteristics
Relapsing-remitting	51	Series of disease relapses followed by distinct recovery periods (complete or partial remission).
Benign	10	Fully functional with no symptoms up to 15 years after diagnosis.
Primary-progressive	9	Gradual progression from initial diagnosis with occasional plateaus. (No distinct remissions)
Secondary-progressive	25	Begins as relapsing-remitting followed by a gradual decline in function.
Progressive-relapsing	5	Progressive decline with clear acute attacks.

Table 1: MS types and characteristics (Dalgas 2011 and Mulcare and Jackson 2006)

Early researchers have advocated that MS patients should avoid any physical activity with fear of exasperating the condition (Sutherland and Anderson 2001). Newer research has determined that not only is there little risk to performing prescribed exercise, it has also been found that regular progressive exercise can actually have a positive impact on MS sufferers (Andreasen et al 2011).

Two of the most common symptoms recorded by MS patients are fatigue, which is described as “a lack of physical and/or mental energy that is perceived by the individual or the caregiver to interfere with usual and desired activities” (Andreasen et al. 2011 pp. 1041) and muscle weakness, both of which are frequently described by MS sufferers as the most detrimental features, with 55% of patients reporting fatigue as their worst symptom (Fisk et al 1994). It is important for research to determine the most appropriate strategies to manage MS patients. One intervention that is receiving a lot of attention within the literature is strength training, with many studies implementing various protocols to improve muscle strength to potentially reduce weakness and fatigue (Rietberg et al 2011).

In this review, a systematic literature search on this specific topic is presented. The aim of this is to identify studies that evaluate the effectiveness of strength training on muscle weakness and fatigue in patients with MS.

Methods

The following outlines the criteria for considering studies for this review.

Studies

The current review will be limited to Randomized Controlled Studies (RCTs). RCTs have been defined as studies where researchers allocate eligible participants to treatment and control groups on a random basis (Clarke and Oxman 2000).

Participants

This review will include studies containing males and females aged 19-45 with a clinical diagnosis of MS. To be included in this review participants should be in remission or have minor symptoms (i.e. able to ambulate independently and perform activities of daily living with minimal disruption). Participants should score <7 on the Expanded Disability Status Scale (EDSS). Participants taking medication to manage their symptoms were also included.

Interventions

Studies evaluating the effects of strength training interventions on MS patients and also the effect it may have on fatigue exasperation or improvements. According to the American College of Sports Medicine (ACSM) guidelines an effective method of strength training on individuals with MS is 2-3 sessions per week with exercises consisting of 1-3 sets of 10-15 repetitions (Mulcare and Jackson 2006). Studies utilizing this protocol over a period of 3-16 weeks will be included. Other protocols included are comparison of endurance and strength training, aerobic fitness and strength training. Supervised and un-supervised (Home based exercise) will also be included.

Outcome Measures

Outcomes including clinical physiological testing (i.e. % strength increases) and patient self-reporting (i.e. functional improvements measured via interviews/questionnaires) will be included in the review.

Search Methods used to identify studies

Electronic Search

RCTs, meta-analysis and systematic reviews, will be identified by searching the following electronic databases. The studies will be limited to publications from the last 5 years.

- The Cochrane Central Register of Controlled Trials (CENTRAL) 2006-present
- PubMed 2006-present
- Scopus 2006-present

Other Resources

In addition to the electronic search a manual search of the reference lists of the selected studies will be conducted along with a manual search of the Multiple Sclerosis Journal since 2006.

Data Collection and Extraction

Titles and abstracts of each of the identified studies were screened for inclusion and subsequently the full text was located for further analysis. Irrelevant publications were discarded at this point. The retrieved publications were reviewed further to ensure they conformed to the studies inclusion criteria.

For each of the identified studies the following information was extracted from the study: Study, sample size/group allocation, design, disability score, procedure, intervention, outcome, and main findings.

Results

A review of the literature revealed 18,444 papers, and once limits were applied 11 papers were included in the review. Figure 1 demonstrates the exclusion process for paper selection. A number of studies examined the effect strength training can have on improvements of MS symptoms, with particular reference to fatigue (Andreasen et al 2011) and functional performance (Dalgas et al 2009). Interventions, which have proved popular with researchers, are progressive resistance training (Dalgas et al 2010), Cycle ergometer (Cakit et al 2010), Hydrotherapy (Castro-Sanchez et al 2012) and a combination of therapies (Bjarnadottir et al 2007). Table 2 includes an overview and details of the studies included in the review.

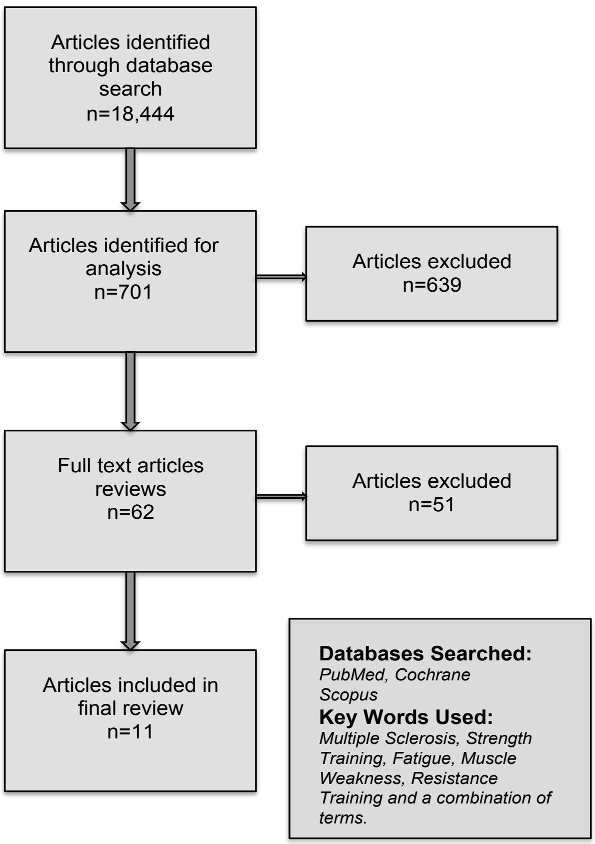

Figure 1: Flow chart of included studies.

Study/Year	Sample Size	Design	(EDSS)	Procedure	Intervention	Outcome	Main Findings
Broekmans et al (2010)	n=36 (n=14 (Control), n=11 (RESO) and n=11 (RESE)) Subject allocation was blinded, results were not disclosed to participants or researchers until conclusion of study.	RCT	2.0-6.5	Pre/Mid/Post D1: unilateral skeletal muscle performance testing on isokinetic dynamometer. D2: Functional Evaluation (TUG), (T25FW), (2MWT), (FR) and (RMI) D3: Neurological Consultation and registration of percieved fatigue	20 Weeks (2 10 week blocks) Control group: maintained their normal habits. RESO: Resistance training without simultaneous electro-stimulation. RESE: Resistance training with simultaneous electro-stimulation. Resistance protocol was in acordance with ACSM prescription for healthy adults	99% compliance with training program. Gradual increase in training load in both RES groups (NS) Significant increases in strength in the RES groups compared to control, No differences were reported between the 2 RES groups 4-5% increases in strength which was sig compared to control. Impaired legs improved significantly 18% improvements in strength.	long term resistance exercise was found to benefit individuals with MS, improvements in muscle strength was found. No effect was found when applying simultaneous electro-stimulation.
Dalgas et al (2010)	n=31 (n=15 (Exercise), n=16 (Control), n=28 of total subjects had biopsies)	RCT	3-5.5	Pre/Post muscle biopsies, Muscle strength testing on isokinetic dynamometer. TV, CSA, DA and PAL. Follow up data taken at 24 weeks (Data not included)	12 weeks, control group maintained normal regiem, Exercise group performed progressive resistance training 2 d.Wk, progressing from 15RM to 8RM, 5min warm ups followed by series of lower body exercises, all sessions were supervised.	CSA of exercise group increased 15.4% vs 9%, type 2 muscle fibres increased 19.4% vs 15.5. strength in exercise group improved significantly when compared to control group 21.3%. There was no change in TV in both groups.	A supervised progressive resistance program can have a positive impace on individuals with a central nervous system disorder such as MS.
Duyur et al (2010)	n=45 (n=15 (Group 1), n=15 (Group 2), n=15 (Control)	RCT	<6	Pre/Post DoE, TMW TUG, DGI, FR, FES, 10MWT, FSS, BDI and SF36	8 weeks, Control group maintained normal habits. Group 1 performed progressive resistance training on a cycle ergometer (15 sets of 2min high resistance pedalling) with 25mins of balance training. Group 2 performed a home based program involving the same balance protocol as group 1. both exercise groups performed sessions on 2 d.Wk.	Group 1 improved in DoE, TMW, TUG, FSS and BDI. Group 2 improved on DoE, TMW and FES. Group 1 scored significantly higher on all variables except 10MWT than the other 2 groups. Group 3 had no improvements post intervention.	Exercise programs including cyclyng with progressive resistance may improve balance, fatigue and depression and reduce fear of falling in MS patients. No exasperations were found during testing.
Castro-Sanchez et al (2011)	n=73 (n=36 (EG), n=37 (control))	RCT	<7.5	Pre/ immediately post treatment/ week 4/10/20/24 and 30 PM: VAS, PRI, PPI, MPQ, RMDQ SM: Spasm VAS, MSIS, MFIS, FSS, BDI and BI	20weeks. EG Ai Chi hydrotherapy program 2 d.Wk 16 movements, shoulder deep in the water, while listening to music. Control group performed the same exercises but on a mat and without music. All sessions were supervised.	EG demonstrated significant decreases in pain intensity vs baseline. Improvements in spasm, fatigue, disability and autonomy were also documented in the EG.	Utilizing hydrotherapy as a means to increase strength in MS patients was found to have a positive effect on spasm, fatigue, disability, depression and atonomy.

Table 2: Study details meeting inclusion criteria

Study/Year	Sample Size	Design	(EDSS)	Procedure	Intervention	Outcome	Main Findings
Dalgas et al (2009)	n=38 (PRT n=19, control n=19)	RCT	3-5.5	Pre/post/12 follow up isokinetic muscle strength testing. And functional capacity	12 weeks, Control group continued normal routine for first 12 weeks. PRT group performed 2 d.Wk on lower body. 3 sets of 10 to 4 sets, all sessions were supervised. Both groups were re tested at 24 month follow up.	The PRT group improved in KE MVS and FC at 12 weeks and follow up compared to the control group. The control group were able to reproduce the effects of the exercise group when they performed 12 weeks of PRT at end of the trial.	A progressive resistance exercise program of sufficient duration and intensity can improve muscle strength and functional capacity in patients with MS.
Dalgas et al (2010)	n=31 (EG n=16, control n=15)	RCT	3-5.5	Start, end and follow up. Fatigue (FSS), Mood (MDI), quality of life (PCS, MCS of SF36).	12 weeks, control continued their normal routine. EG performed PRT 2 d.Wk on lower body resistance was progressed by alterng the RM and the seta and reps. All sessions were supervised.	Both groups scores were comparable at beginning. Fatigue levels improved significantly in EG compared to control. Measures of mood and quality of life also were significantly better in the EG compared to the control. Testing at follow up revealed all benefits to be still present after 12 weeks.	Progressive Resistance programe has been found to have significant improvements in fatigue, mood and quality of life in patients with MS.
Bjarnadottir et al (2007)	n=16 (EG n=6, control n=10)	RCT	<4	Pre and post. Physical fitness with peak oxygen consumption, workload and anaerobic threshold, quality of life (SF:36) and degree of disability (EDSS)	5 weeks, control didn't change their training habits, EG trained 3 d.Wk performing in 3 parts (1. cycle ergometer training at anaerobic the=reshold. 2. resistance training, 13 exercises for upper and lower body 15-20 reps. 3. Stretching and relaxation. All sessions were supervised.	the EG demonstrated improvements in peak oxygen consumption (14.7%), Peak workload (18.2%), and anaerobic threshold (27.3%). The EG had improvements in quality of life, however this was not significant.	The study demonstrated that resistance training combined with anaerobic cycling can improve fitness and strength in patients with MS.
Rampello et al (2007)	n=11 (AT n=6, NR n=5)	RCT	<6	Pre and post. Fatigue (MFIS) and quality of life (MSQOL-54) Lung function and respiratory muscle strength (FGC) Tests (6MWTs), (CPETs)	8 weeks, AT group trained 3 d.Wk on cycle ergometer, working at 60% max. The NR group also trained 3 d.Wk performing exercises to improve posture in respiratory function. Exercises were stretching with emphasis on breathing.	6MWT the AT improved significantly compared to the NR group. AT participants showed significant improvements in lung function and respiratory muscle strength compared to the NR group. Both groups showed improvements on the MFIS and the MSQOL-54	AT was found to be more effective than NR in the management of MS patients in improving their quality of life.

Table 2: Continued

Strength Training

Muscle weakness and fatigue are two of the most common symptoms described by MS sufferers (Dalgas et al 2010). Recently research has focused on the implementation of strength training as an intervention to manage MS features (Collett et al 2010 and Hayes et al 2011). Controversy has surrounded the prescription of exercise to MS patients with fear of exasperation of the condition (Dalgas et al 2009). Despite this, researchers have continued to test the hypothesis that exercise will in fact have a positive

Study/Year	Sample Size	Design	(EDSS)	Procedure	Intervention	Outcome	Main Findings
Fimland et al (2010)	n=14 (Control n= 7, MST n-7)	RCT	3-5.5	Pretest and Post test. isokinetic muscle testing and EMG activity.	3 weeks. Control performed traditional rehabilitation program including aqua, gymnastics, stretching, physio and relazation. The MST group trained 5 d.Wk performed traditional rehabilitation alond with a MST program.	The MST group maximal voluntary contraction increased significantly more than the control group Individuals in the MST group increased their efferent motor output of spinal motor neurons.	Performing strength thraining in addition to traditional rehabilitation programs for MS cand have a positive impact on strength and neural responses, which has been thought to reduce neuromuscular symptoms associated to the disease.
Hayes et al (2011)	n=19 (STAND n=7, RENEW n=7)	RCT	<6	Pretest and posttest. Lower extremity strength, Mobility (TUG, TMWSS, TMWMP, S-A, S-D, 6MWT), Balance (BBS), Fatigue (FSS).	12 weeks, STAND completed training 3 d.Wk performing standard training for the lower extremity, including aerobic training, stretching, strength and balance. The RENEW group also trained 3 d.Wk however this group performed high intensity lower extremity eccentric ergonomic exercise. progression of each groups was performed gradually and all sessions were supervised.	The RENEW group had a 15% strength increase compared to the STAND group with 2%. The STAND group improved in mobility and Balance more than the RENEW group. No difference in fatigue was found.	The addition of eccentric exercise to the traditional strength training had no impact on balance or mobility, there was an increase however in the overal strength improvement.
Collett et al (2010)	n=55 (continuous n=20, intermittent n=18 and combined n=17)	RCT	<6	Pretest, during Posttest and Follow up. Function (2MWT, TUG), Barthel Index, SF-36, Fatigue (FSS), blood pressure, and cycle ergometer incremental fitness test.	12 weeks (all groups trained 2 d.Wk). Combined (10min intermittent cycling 30s work/30s rest at 90% peak immediately followed by 10min continuous cycling at 45% peak), Continuous (Continuous cycling for 20mins at 45% peak) and Intermittent (30s work and 30s rest at 90% peak for 20min). All sessions were supervised.	No differences were found between groups overall function was improved over all groups.	With no differences found between the 3 groups, it was not necessary to train at such intensities, the study found a high drop out rate in the higher intensity groups.

Key: RESo: Traditional exercise without electrical stimulation. RESe: With electrical stimulation. RCT: randomised controlled trial. EDSS: Expanded dissability severity scale.
D: Day. TUG: Timed get up and go. T25FW: timed 25ft walk test. 2MWT: 2m walk test. FR: Functional reach. RMI: rivermead mobility index. ACSM: American college of sports medicine. MS: Multiple sclerosis. TV: Thigh volume. CSA: Cross sectional area. DA: Daily activity. PAL: physical activity level. RM: repetition maximum. d.Wk: days per week. TMW: tollerated maximal workload.DGI: Dynamic Gait Index. FES: Falls efficacy scale. 10MWT: 10m walk test. FSS: Fatigue severity scale. BDI: beck depression inventory. SF-36: Short form. DOE: Duration of exercise. EG: Exercise group. PM: primary measures. VAS: Visual Analogue scale. PRI: pain rating index. PPI: present pain intensity. MPQ: McGill pain questionnaire. RMDQ: Rolland morris disability questionnaire. SM: Secondary Measures. MSIS: Multiple sclerosis impact scale. MFIS: Modified fatigue impact scale. PRT: progressive resistance training. KE: Knee extension. MVS: Maximal voluntary strength. PCS: Physical component scale.MCS: mental component scale. AT: aerobic training. NR: Neurological rehabilitation. MSQOL-54: multiple sclerosis quality of life. CPET: Cardiopulmonary exercise tests. EMG: electromyography.STAND: Standard. RENEW: Additional eccentric exercise.

Table 2: Continued

effect on symptoms, and thus far the results have been positive (Andreasen et al 2011). Studies by Dalgas et al (2010a); Hayes et al (2011); Broekmans et al (2010); Dalgas et al (2010b); Dalgas et al (2009) and Fimland et al (2010) examined whether the use of resistance training would impact MS sufferers with particular reference to fatigue and function. The studies used individuals with an EDSS score of between 3.5 and 7.5, interventions consisted of progressive resistance training over periods of 3-20 weeks with 2-5 sessions per week, with varying intensities.

Dalgas and colleagues (2009, 2010a and 2010b) have conducted extensive research into the effects resistance training will have on MS. Each of the three RCT's followed a similar protocol of 12 weeks of progressive resistance training using 2 groups (Exercise and control) and lower body resistance exercises (Leg press, knee extension, hip flexion, hamstring curl and hip extension). The sessions were twice weekly and were supervised. In total 107 participants were involved in the 3 studies (Control n=53 and Exercise n=54) (Table 2). The only of the 3 Dalgas studies examining the effects of training on fatigue was their earlier 2010 work, the study looked at pre and post measures of fatigue using the FSS and the MFI-20, pre intervention no differences were found within the groups, however post intervention a significant improvement was noted in the exercise group when compared to control and pre intervention scores (pre: (CG: 5.5 95% CI 5.0-6.0) vs (EG: 5.8 95% CI 5.4-6.1) NS) and (post: (CG: 5.6 95% CI 4.9-6.3) vs (EG: 5.2 95% CI 4.4-6.0)SIG $p<0.05$). Follow up revealed no additional improvements, however it is also worth noting that the levels gained post intervention were not lost at follow up.

Another study looking at the effects of RT on fatigue is Hayes et al (2011) using a 2 group RCT (Table 2) the study evaluated fatigue levels using the FSS. An improvement was found in the level of fatigue experienced within the two groups, however no differences were found between the different interventions (RENEW: (Pre: 6.1 vs Post: 5.1) and STAND: (Pre: 5.8 vs Post 4.5)NS $p>0.05$). While both the Dalgas and Hayes studies provide evidence on improvements in fatigue the Hayes et al (2011) study was limited in the fact that no control group was used, all groups involved performed some form of exercise, albeit varying intensities and protocols.

6 out of the 11 reviewed studies looks at the effect of RT on functional outcome (table 2). The three Dalgas studies performed the same protocol, progressive resistance training (table 2). Fimland et al (2010) utilized maximal strength training, Broekmans et al (2010) looked at whether strength training with or without electrical stimulation would have an effect. Finally Hayes et al (2011) utilized two relatively new protocols comparing high intensity eccentric exercise to traditional RT. All of the above studies aimed to determine whether participants function would improve post intervention. All of the studies except Broekmans et al (2010) and Hayes et al (2011) found that implementing an RT program has a positive impact on function and a significant difference was recorded between groups, especially when compared to a control group (continued own daily routine). While the Broekmans and Hayes studies did indicate improvements in function, there was no significant findings between groups, they found that the addition of eccentric training (Broekmans et al 2010) or electro-stimulation (Hayes et al 2011) showed no additional improvements or benefits.

Several limitations exist in the above studies including the use of limited disability severity, all of the included studies included restricted participants to EDSS scores of <7.5 with only one study being above 6. The limited data on more severe cases of MS directs the reader to proceed with caution when applying the data to MS populations out with the EDSS scores evaluated. Another limitation that exists is the small sample sizes utilized, it is difficult to apply results of studies to larger populations. Utilization of larger groups may have demonstrated greater more statistically relevant findings. Two of the studies (Fimland et al 2010 and Hayes et al 2011) failed to include a control group, without this it is difficult to determine whether the results found were in fact due to the exercise prescribed or by chance.

Aerobic Training

Other interventions described to improve strength in MS patients is through the use of cycle ergometry (Rampello et al 2007, Collett et al 2010 and Cakit et al 2010). Researchers have thought that through varying intensities on a cycle you can gain similar benefits to strength training, with the added benefit of cardiovascular improvements (Bjarnadottir et al 2007). Limited function and fatigue in MS patients can often lead to poor locomotor function, patients often see a decline in the length of time they are able to ambulate (Dalgas 2011). Cycling has been described as having similar mechanics and muscular patterns as walking, therefore it has been found to be an effective method to improve strength and function in MS sufferers (Cakit et al 2010).

In 2007 Rampello and colleagues examined the effect a cycle training program had on walking capacity and maximum exercise tollerance in patients with MS. The RCT evaluated the differences between aerobic training (Cycle ergometer) and neurological rehabilitation (breathing patterns and stretching). The study found that implemetation of an 8 week cycle protocol had a positive effect on not only walking distance (AT (Pre: 308m and Post: 332m) SIG $p<0.05$ vs NR (Pre: 298m and Post: 308m) NS) but also exercise tollerence, the patients in the aerobic training group described enhanced function when compared to the neurological rehabilitation group. The study found no significant differences between groups in relation to fatigue. The study did however find improvements in fatigue in both the groups. The results of the Rampello et al (2007) study support that exercise prescription can yield positive effects on MS patients, the researchers could have strengthened their findings by including a control group, where no exercise was completed, thereby enabling a more statistically relevent conclusion to be made.

A similar, more recent 3 group RCT was conducted by Cakit et al (2010) to evaluate the effects of progressive resistance training with a cycle ergometer and balance exercises compared to a home based protocol of lower limb strength and balance exercises on function and fatigue in a group of MS sufferers. One outcome measure evaluated was fatigue, the study revealed improvements in both exercise groups, however it was group 1 which, scored higher than the other 2 groups (Pre: 39.8 – Post: 30.2; SIG $p<0.05$). Both exercise groups saw an improvement in function overall, but it was group 1 who saw the greater gains. No change was noted in the control group in any outcome measure. In the Cakit et al (2010) study group 1 was supervised and group 2 was un-supervised (Home based). Evidence has suggested that individuals are more likely to adhere to supervised protocols than unsupervised (Granquist et al 2010). This was apparent in the above study as adherence in group 1 was 93% whereas the un-supervised group 2 was only 60%, this may explain the greater improvements in group 1 over 2, and whether they came from an improved protocol or the improved adherence rate.

It has been suggested in the literature that exercise intensities can often be too conservative when managing patients with neuromuscular conditions such as MS (Collett et al 2010 and Dalgas 2011). A recent study by Collett and collegues (2010) evaluated the effect of cycling at different intensities on the symptoms of MS. Three different exercise intensities (Continuous, intermittent and combined) were prescribed over a 12 week period. Walking distance was used to determine effects of the intervention. The study found that walking distance improved overall (6.96m (95% CI 1.81 to 12.10), interestingly there were no differences found between groups, however the authors concluded that the higher intensity protocol may yield the best improvements, especially in the first 6 weeks. The study did report that the higher intensity exercise did exacerbate some individuals symptoms, however carefully planned routines, taking into consideration the individuals disability and whether the long term benefits would outweigh the initial discomfort would strengthen future research.

Other Interventions

The majority of the exercise prescription in MS has focused on either traditional strength training or improving strength and function through cycling. limited research exists examining what a combined approach would make. One study by Bjarnadottir et al (2007) utilized this by combining strength training with cycling, compared to a control group. Individuals performed the exercise intervention for 5 weeks, outcomes were to establish any improvements in fitness and quality of life, it was found that the exercise group experienced enhancements in quality of life, however no significance was found between groups. The study included 10 participants in the control group, compared to only 6 in the exercise group, this group difference could have resulted in the outcome of the study, as there was improvements detected, indicating if groups were a little larger or more equal, these differences may have been significant.

New in the MS research is the use of hydrotherapy to manage and improve symptoms. Castro-Sanchez et al (2012) undertook an RCT to examine the effects hydrotherapy has on MS patients symptoms in comparison to land based exercise therapy. The intervention lasted 20 weeks and all sessions were supervised. The study examined individual levels of pain and fatigue, it was found that the hydrotherapy group had significant improvements in pain and fatigue levels when compared to control groups. The improvements noted were also maintained after a 10 week follow up. The use of hydrotherapy has been found to be beneficial in managing patients with painful neurological and musculoskeletal conditions (Castro-Sanchez et al 2012). While there is a plethora of research on the use of hydrotherapy to treat various injuries, further research is necessary to determine the benefits of hydrotherapy protocols in patients with MS.

Discussion

The results of the present review revealed that the prescription of exercise, to patients with MS is no longer the controversial issue it has been (Andreasen et al 2011). In fact evidence suggests that getting involved in some exercise could actually improve an MS patients quality of life (Dalgas et al 2009, 2010a and 2010b). MS sufferers consistently describe fatigue and muscle weakness as their most debilitating symptoms, with the results of this review supporting the hypothesis that regular progressive resistance training can improve muscle weakness and reduce fatigue, therefore improving individuals quality of life (Dalgas et al 2009, 2010a).

With regard to rehabilitation, progressive resistance training is the most common protocol examined in MS research; the current review revealed that the implementation of strength training protocols including weight training (Dalgas et al 2009, 2010a and 2010b), cycle ergometer (Rampello et al 2007), and a combination (Bjarnadottir et al 2007) had some positive conclusions. While some researchers couldn't find any additional benefit to adding other modalities to the treatment, such as eccentric exercise (Broekmans et al 2010) or electro-stimulation (Hayes et al 2011), they were all in agreement that implementing a strength training program had a positive impact on MS sufferers.

Studies by White et al (2004) and Onambele and Degens (2006) evaluated whether strength training had any effect on MS patients levels of fatigue and function. The White et al (2004) study implemented a bi-weekly, 8-week strength training program, testing was done pre and post intervention. Onamble and Degens (2006) also evaluated a strength training protocol, however theirs was done over a 16-week period, 3 times per week. Both studies found and improvement in levels of fatigue and function post testing, this was in agreement with the current review, as all but one study reviewed found a positive improvement in fatigue and overal function.

While the results of not only the current review, but the results of earlier studies show positive attributes to this field, disparity exists within the methodologies used, Dalgas and colleagues use guidelines set by the ACSM while other researchers reproduce protocols set by other studies (Broekmans et al 2010). Previously researchers have included various guidelines for their exercise prescription, Fimland et al (2010) looked at the effects strength training had over a 3-week period, performing exercises 5 days per week. While Broekmans et al (2010) implemented a 20-week strength-training program with or without electro-stimulation, working out 5 days per week. While the present review supports the prescription of strength training to patients with MS, further standardization is required in the protocols used to evaluate the effectiveness.

Another modality commonly used to improve strength and function in MS sufferers is the prescription of aerobic training, utilizing a cycle ergometer due to the mechanics being similar to those used in locomotion (Cakit et al 2010). Early research into strengthening patients and reducing MS symptoms has typically focused on strength and resistance training (White et al 2004 and Onambele and Degens 2006). Newer researchers have demonstrated that strength gains can be had through cycling, varying the intensity and speed of cadence (Collett et al 2010 and Cakit et al 2010). While the use of cycle ergometer to improve strength has been around for many years, its inclusion within the MS literature is relatively new (Collett et al 2010 and Cakit et al 2010), one possible reason for this would be that the application of cycle training has reduced weight bearing, which is an essential skill for locomotion (Cakit et al 2010). Individuals who score low on the EDSS scale may not be appropriate subjects for this as improvements in locomotor strength may be their desired outcome. Individuals with a high EDSS score >7.5, may benefit greatly from cycle based training, as there is little stress placed upon the joints. With the majority of MS literature utilizing individuals below 6 on the EDSS It is not known whether this statement would in fact improve this population, further research is required using appropriate subjects to test this hypothesis.

Categorization of disability level in MS patients is typically by the EDSS, which is a scale of 1-10 with 1 being relatively minimal disability to 10, which could include death. Studies examining the effectiveness of exercise on MS symptoms typically include patients with a score of less than 6, which is characterized as being able to ambulate independently without aid for at least 20 meters. The current review found no studies, which included patients above 7.5, with only one being above 6. A review by Andreasen et al (2011) also only included individuals under a score of 6. Reasons for this exclusion is however unknown, and readers should proceed with caution when applying the findings of the current research on patients with an EDSS score >6.

Future research needs to include a wider range of disability, to determine what effect strength training could have to this population.

Conclusion

MS is a common and debilitating condition affecting approximately 2.5 million people worldwide (Kumar et al 2011). New and promising research suggests that the implementation of a strength training protocol can reduce patient's symptoms, namely fatigue and muscle weakness, with the majority of earlier research declaring that performing exercise would be detrimental to the condition, it is actually becoming increasingly encouraged that individuals should partake in some physical activity. Protocols adopted by researchers vary in intervention period, exercise intensity, frequency and type of activity; future research needs to establish whether certain protocols are more effective than others. Contradictory to earlier research the current review does support the hypothesis that strength training can improve MS patient's quality off life, albeit future studies require tighter methodologies and larger sample groups.

Future Recommendations

An often-overlooked component of MS research is the participant's activity level prior to disease diagnosis, were they actively participating in sport? Did the disease diagnosis cause them to cease training? Would prior activity participation affect the disease progression? And would they be able to participate in higher intensity exercise? No research to date has explored any of the above questions, with the improvement of sporting facilities; especially in disabled sport, future research should aim to address these vital questions.

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