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REVIEW ARTICLE - EXERCISE IN RMD

The relevance of applying exercise training principles when designing therapeutic interventions for patients with inflammatory myopathies: a systematic review

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Abstract Physical exercise seems to be a safe and effective intervention in patients with inflammatory myopathy (IM). However, the optimal training intervention is not clear. To achieve an optimum training effect, physical exercise training principles must be considered and to replicate research findings, FITT components (frequency, intensity, time, and type) of exercise training should be reported. This review aims to evaluate exercise interventions in studies with IM patients in relation to (1) the application of principles of exercise training, (2) the reporting of FITT components, (3) the adherence of participants to the intervention, and (4) to assess the methodological quality of the included studies. The literature was searched for exercise studies in IM patients. Data were extracted to evaluate the application of the training principles, the reporting of and the adherence to the exercise prescription. The Downs and Black checklist was used to assess methodological quality of the included studies. From the 14 included studies, four focused on resistance, two on endurance, and eight on combined training. In terms of principles of exercise training, 93 % reported *specificity*, 50 % *progression* and *overload*, and 79 % *initial values*. *Reversibility* and *diminishing returns* were never reported. Six articles reported all FITT components in the prescription of the training though no study described adherence to all of these components. Incomplete application of the exercise training principles and insufficient reporting of the exercise intervention prescribed and completed hamper the reproducibility of the intervention and the ability to determine the optimal dose of exercise.

Keywords Myositis · Inflammatory myopathy · Aerobic exercise · Resistance training · Training principles · Training components

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Abbreviations

DM	Dermatomyositis
FITT	Frequency, intensity, time, and type of exercise
IBM	Inclusion body myositis
IM	Inflammatory myopathies
PE	Physical exercise
PM	Polymyositis
RCT	Randomised controlled trail
RPE	Rating of perceived exertion and pain

Introduction

Dermatomyositis (DM), polymyositis (PM), and inclusion body myositis (IBM) belong to inflammatory myopathies (IMs), a group of autoimmune syndromes leading to chronic diseases of the musculature characterised by proximal muscle weakness. IM may also be present as a part of a multisystem disorder in other connective tissue diseases, most commonly scleroderma, systemic lupus erythematosus, mixed connective tissue diseases, and Sjögren Syndrome [1]. Several epidemiological studies report incidence rates varying widely between 0.1 and 7.89 cases per 100,000 annually [2–4]. Interestingly, recent publications show a higher incidence rate than previous studies, indicating increased awareness of this disease but also improved screening methods [5]. Although relatively rare, IMs pose a significant economic burden causing increased medical costs and resource usage as well as high patient burden [6, 7]. The most prominent clinical features in all subcategories of IM are proximal and (often) symmetric muscle weakness and low muscle endurance, combined with progressive decline over a period of weeks or months. These features result in significant disabilities [8, 9]. Patients often report increasing difficulties in performing everyday tasks, such as self-care or household chores, combined with limited community mobility [1, 8]. Additionally, muscle weakness is a known risk factor for postural instability and falls [10, 11], and there is evidence that falling is common in patients with IBM [8]. The benefit of targeted physical exercise (PE) in patients with IM has been acknowledged and resulted in the inclusion of physical training which aims to improve performance without exacerbating disease progression in recognised treatment recommendations [2, 12, 13]. PE is a safe intervention and may not only improve strength and endurance but also seems to have anti-inflammatory, anti-fibrotic, and positive metabolic effects [2, 14–19]. An important prerequisite for PE to be effective is, however, the adherence to principles of exercise training [20–22]. A systematic review investigating the safety and efficacy of exercise in IM patients reported indecisive results [23]. Up to now, the published reviews describing exercise training in IM focused on safety and efficacy of physical exercise interventions, but did not critically evaluate the application of the principles of exercise training or the adherence to the prescribed exercise programme in a structured manner.

When reporting the results of a PE intervention, it is important to provide precise information regarding the core principles of PE training that were used and considered [20, 21]. Without a detailed and comprehensive description of the interventions, research findings cannot be used for replication in other studies or implementation in clinical daily routine [24]. The recognised principles of PE are specificity, overload, progression, initial values, reversibility, and diminishing returns (Table 1) [25]. Their implementation in the design of a PE intervention helps to ensure that an appropriate dose and type of exercise is utilised to achieve a desired outcome, be this improvements in cardiorespiratory endurance, muscular strength, or balance. Besides considering these core principles, it is also important to report the components of the exercise programme. Only if training is reported with this level of detail can appropriate study conclusions be drawn as well as intervention replication guaranteed. The components of a PE programme can be reported using the FITT components (frequency, intensity, time, and type of exercise) [26]. Furthermore, the adherence to the described FITT components should be captured and reported. Without reporting the adherence to the prescribed exercise programme, the dose that was delivered remains unclear. Therefore, the prescription of the components of the exercise programme as well as participants' adherence to that exercise prescription need to be reported in sufficient detail. Moreover, when principles of exercise training are applied to the development of exercise protocols, clinicians can assume that studies where the intervention of interest demonstrates a lack of significant effects reveal shortcomings in exercise efficacy rather than shortcomings in exercise prescription [21, 22]. Some of the shortcomings of knowledge related to exercise implementation in IM patients might relate to the lack of consideration of exercise principles in the trials published so far.

Besides a specific and clearly planned and described intervention, other factors such as the design and methodological quality of a trial may influence study outcome. Well-designed randomised controlled trials provide the best evidence regarding the effectiveness of health-care interventions, whilst inadequate methodological approaches may overstate treatment effects and bias results [27]. Although non-randomised studies are more susceptible to confounding, their results in comparison with those of randomised trials may sometimes differ [28]. Furthermore, for some rare diseases, there may in any event be too few RCTs to answer the question of interest, thus necessitating that non-randomised trials also be included in review work.

Table 1 Exercise training principles [25]

Principle	Criteria for this review	Example
Specificity		
Training adaptations are specific to the system or muscles trained with exercise	Appropriate population targeted and intervention given based on primary outcome	Aerobic exercise such as brisk walking is more appropriate for an intervention aimed at increasing cardiovascular fitness than strength training
Progression		
Over time, the body adapts to exercise. For continued improvement, the volume or intensity must be increased	Stated exercise programme was progressive and outlined training progression	A walking intervention 2×/week at 60 % of maximum heart rate for 30 min, adds 5 min/week over 6 weeks
Overload		
For an intervention to improve fitness, it must be greater than what the individual is already doing	Rationale provided that programme was of sufficient intensity/exercise prescribed relative to baseline fitness	An individual currently cycles 30 min 2×/week; the exercise intervention must be of greater volume to see a significant improvement in fitness
Initial values		
Improvements in the outcome of interest will be greatest in those with lower initial values	Selected population with low level of primary outcome measure and/or baseline physical activity levels	Those with lowest level of fitness have greatest room for improvement. A sample with high fatigue level will be more likely to see a significant change than a sample with low baseline fatigue
Reversibility		
Once a training stimulus is removed, fitness levels will eventually return to baseline	Performed follow-up assessment on participants who decreased or stopped exercise training after conclusion of intervention	"Use it or lose it". Strength gains achieved over 1 year of resistance exercise may completely reverse within a number of months of inactivity
Diminishing returns		
The expected degree of improvement in fitness decreases as individuals become fit, thereby increasing the effort required for further improvements	Performed follow-up assessment of primary outcomes on participants who continued to exercise after conclusion of intervention	Non-exercisers who begin an exercise programme are likely to experience large initial gains, but the magnitude of change will decrease over time. Also known as the "ceiling effect"

Irrespective of study design, study quality should be evaluated in a standardised manner.

This review evaluates exercise interventions in populations suffering from IM in randomised controlled, non-randomised controlled, and uncontrolled trials investigating the effect of resistive, endurance, or balance training alone or in combination in relation to (1) the application of principles of exercise training in developing the exercise prescription, (2) the reporting of FITT components of the exercise prescriptions, (3) the adherence of participants to the prescribed intervention and to gauge (4) the methodological quality of the included studies.

Methods

Search strategy

An electronic search strategy was developed and performed by a librarian of Zurich University for the databases MEDLINE/PreMEDLINE, CINAHL, PsychINFO, EMBASE, and the Cochrane Library. The search was restricted to English, German, French, and Dutch language literature from inception of the databases up to January 2015 ("Appendix in Electronic Supplementary Material"). Combinations of medical subject headings (MeSH) and free text words related to inflammatory myopathy (inflammatory myopathy, dermatomyositits, polymyositis, inclusion body myositis, sclerodema, systemic sclerosis, systemic lupus erythematosus, Sjögren's syndrome) and exercise (e.g. exercise, endurance training, cardiovascular training, cardiopulmonary training, cardiorespiratory training, aerobic training, endurance exercise, ergometry, cycling, rowing, treadmill, resistive strength training, muscle strength training, weight-lifting strengthening programme, weight-bearing strengthening programme, flexibility training, balance training, physical exercise principles, specificity, overload, progression, initial values, reversibility, diminishing returns) were used. The search results were supplemented by articles found through hand searching by scanning reference lists of identified studies.

Eligibility criteria

Studies were eligible for inclusion if they: (1) included adult (≥18 years) patients with an idiopathic or an associated inflammatory myopathy, (2) were randomised controlled trials, non-randomised controlled trials, or uncontrolled trials, (3) evaluated the effect of resistive, endurance, or balance training alone or in combination, (4) included aerobic capacity and/or aerobic endurance, muscle strength and/or balance as a primary outcome measurement. Case series or case reports were excluded. Hands-on intervention therapies alone (i.e. mobilisation, passive movements, stretching without physical exercise), as well as relaxation training, were not considered in this review.

Study selection

After removal of duplicates, the search results were screened for eligibility by a team of two reviewers (PB/RHK), sharing the retrieved citations. In case of disagreement between the two reviewers, a third party (BCT) served as referee. Reports of secondary analyses or on extensions from original manuscripts were not included in this review.

Data extraction and synthesis

Information on the study design, number and diagnosis of participants, type and length of intervention, and the intervention protocol were extracted from each publication. Details of the intervention protocol were abstracted using a purpose adapted data collection sheet based on systematic reviews evaluating the effects of physical exercise interventions in cancer [21] and stroke patients [22]. It included reporting of PE training principles, description of exercise training components, and participants' adherence to the training plan according to the FITT components. For each physical exercise principle, three rating categories were used, these being yes (+) "reported", no (NR) "not reported", and (?) "unclearly/inconsistently reported". Corresponding to the rating of the training principles, the description of each of the four FITT components was judged with (+) if the component of the exercise prescription was reported, (NR) if the component was not reported, and (?) if it was unclearly or inconsistently reported. Participants' adherence to the exercise prescription was judged with (+) if adherence to each component of the exercise prescription was reported, (NR) if adherence was not reported, and (?) if it was unclearly or inconsistently reported. Two reviewers (BCT, PB) independently collected and rated these data. In case of discrepancies, a third reviewer (RHK) was used as an adjudicator.

Study quality assessment

Methodological quality of all studies was assessed by two independent reviewers (PB and BCT) using the checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health-care interventions developed by Downs and Black [29]. This scale contains 27 items assessing five subscales, these being **reporting** (10 items), **internal validity-bias** (seven items), **internal validity-confounding** (six items), **external validity** (three items), and **power** (one item). We modified the scoring of the last item (*study power)* from a 0–5 scale to a 0–1 scale where 1 was scored if authors reported if and how they determined their sample size a priori [30]. Item 4 (*description of the intervention*) and 19 (*compliance with the intervention*) were scored "yes" if all FITT components were described in the method and results, respectively. According to other recommendations [31], we scored item 26 (losses to follow-up) "yes" if the drop-out rate was <15 %, or if an intention-to-treat analysis was conducted. The score from this modified version ranged from 0 to 28, with a higher score indicating higher methodological quality. For intervention studies with a one-group design, several items must be scored zero (items 5, 14, 15, 21–25), which implied a possible range score between 0 and 19 for those study designs. The arbitration of a third reviewer (RHK) was used in the event of any disagreement between the reviewers (BCT and PB) for the ratings. The percentage agreement and Cohen's kappa were calculated and interpreted in accordance with Landis and Koch's benchmarks for assessing the agreement between raters, categories being poor (0), slight (0.1–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect (0.81–1.0) [32]. The PRISMA statement was followed for reporting items of this review [33, 34].

Results

Study selection and characteristics

The literature search provided a total of 1371 citations. After screening and checking for duplicates, 16 reports [20, 34–48] met all of the inclusion criteria [35–50]. Two reports were classified as a secondary analysis [43] or an extension [36] from an original study and were therefore excluded from this review (Fig. 1). Finally, 14 reports [35, 37–42, 44–50] evaluating 190 patients remained. Thirteen patients were evaluated in two studies; a 6-week randomised controlled trial [49] and a 6-month follow-up trial [50]. Relevant information was extracted (Table 2). Nine reports [20, 34, 36–38, 40, 46–48] investigated patients with DM and PM [35, 37–40, 42, 48–50], four reports [39, 43–45] included patients with IBM [41, 45–47], and one report [44] evaluated PM, DM, and IBM patients. In total, 161 DM and PM patients (121 in a chronic stage and 40 with recent disease onset) and 29 IBM patients were examined. Four reports (two PM/DM [38, 48], two IBM [46, 47]) focused on resistance training, two on endurance training (two PM/DM [49, 50]) and eight reports (five PM/DM [35, 37, 39, 40, 42], two IBM [41, 45], and one PM/DM and IBM [44]) on combined interventions of aerobic and resistance exercises. No study evaluated the effects of balance training. All but five studies used a one-group study design, from which were four RCTs [35, 37, 42, 49] and one [50] was a controlled trial without randomisation procedure. One RCT [42] compared a combination of PE/oral creatine supplements against PE/placebo. Both groups performed the same exercise programme, making a comparison between the two groups concerning the effects of PE impossible. The length of the exercise programmes varied between 3 weeks [44] and 6 months [42, 50] (median: 12 weeks). Exercise frequencies ranged from twice daily [46] to twice per week [49–51]. Half of the studies evaluated a home exercise programme [37, 39–42, 45, 46] and the other half a supervised exercise programme in dedicated training facilities [36, 38, 44, 47–50].

Application of exercise principles

The application of exercise principles is summarised in Table 3. None of the articles reported all six training principles, five articles [20, 38, 46, 47, 50] reporting four, four articles [37, 40, 42, 48] reporting two and three articles [35, 39, 45] reporting three. The remaining two articles reported 0 [42] or 1 [39] principle. In two articles [35, 37], the training principles ***Reversibility*** and ***Diminishing Return*** were reported inconsistently. Thirteen articles [35, 37–42, 45–50] reported ***Specificity***, 11 articles [35, 37–40, 42, 45–47, 49, 50] described ***Initial Values***, whilst seven articles described ***Progression*** [38, 39, 45–47, 49, 50] and ***Overload*** [35, 38, 45, 47–50]. Articles focusing on one training method alone (either strength [38, 46–48] or endurance training [49, 50]) reported more training principles (mean 3.7 ± 0.8) compared to those with a combined intervention [35, 37, 39–42, 44, 45] (mean 2.1 ± 1.2).

Reporting of the prescription of the physical exercise training

Reporting of the prescriptions of the training programme according to the FITT components as well as its adherence is presented in Fig. 2. Six articles [35, 38, 47–50] reported all four FITT components, five articles [37, 39–42] described three components, two articles [45, 46] reported two components, and one article [44] described 0 components. ***Frequency*** and ***Type*** were described in 13 articles [35, 37–42, 45–50], ***Time*** in 11 articles [35, 37–42, 47–50], and ***Intensity*** in seven articles [35, 38, 45, 47–50]. The quality of reporting of the intervention was better in studies focusing on only one training method compared to those including a combination of strength and endurance training (mean of 3.7 ± 0.8 vs. 2.6 ± 1.2 FITT components out of four).

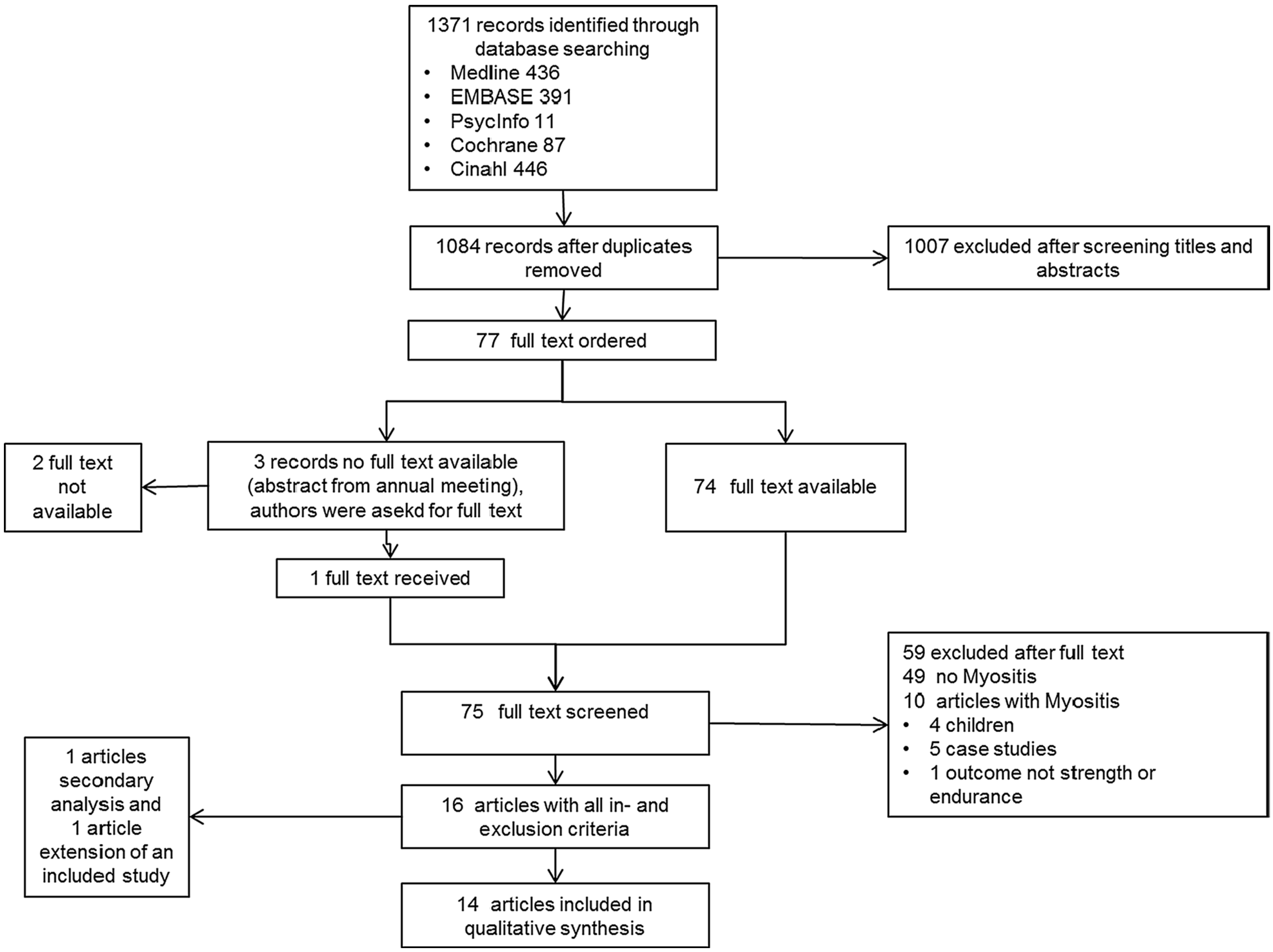


Fig. 1 Flow chart of study selection process

Adherence to the exercise prescription according to the FITT components

Four articles [37, 39, 41, 46] reported two out of four training components, one report [38] described one component, and nine reports [35, 40, 42, 44, 45, 47–50] did not describe the adherence of the patients to the PE programme. ***Frequency*** was reported in five [37–39, 41, 46] and ***Type*** in four reports [37, 39, 41, 46]. ***Intensity*** and ***Time*** were not mentioned in any of the included reports.

Methodological quality

The methodological quality varied widely between the reports (Fig. 3). Studies using a one-group design [38–41, 44–48] scored between 11 and 15 (mean 12.75 ± 1.3) points (maximum possible score 19). Reports with a two-group design [35, 37, 42, 49, 50] scored between 19 and 24 (mean 21.6 ± 1.8; maximum possible score 28). The subscales **internal validity-confounding** had the highest quality score (86 % yes answers), followed by the subscales **internal validity-bias** and **reporting** (each 78 % yes answers), whilst **external validity** and **power** scored lowest (only 48 % respectively 40 % yes answers). In the subscale **reporting**, the item “intervention of interest” was described in six reports [35, 38, 47–50] and “actual *p*-values” were stated in five reports [35, 42, 44, 45, 50]. The items “hypothesis/aim/objective”, “main outcomes to be measured”, and “main findings” were described in all 14 reports. In the subscale **external validity**, eight reports [37–39, 42, 44, 48–50] stated if the subjects asked to participate were representative of the entire population, whilst only four reports [44, 48–50] described whether participants were representative of this population. One report [42] described the blinding of their patients regarding intervention. None of the reports provided an account of participant adherence. The total inter-rater agreement was good (kappa 0.62, SE of kappa: 0.054, 95 %CI 0.51–0.72). The number of observed agreements between the two raters was 86.93 % of the judgements. The kappa of the subscales

Table 2 Description of studies

Study	Design	N and diagnosis	Type of intervention	Control	Length	TP	FITT rep	FITT adh	D & B
Aerobic and resistance									
Alexanderson et al. [40]	1 group	10 PM/DM (chronic) (5 PM/5 DM)	Home exercise programme (strength and mobility exercises and 15 min walk)	–	12 weeks	2	3	0	11/19
Alexanderson et al. [39]	1 group	11 PM/DM (acute) (7 PM/4 DM)	Home exercise programme (strength exercises and 15 min walk)	–	12 weeks	3	3	2	14/19
Heikkilà et al. [44]	1 group	22 DM/PM/IBM (15 PM/4 DM/3 IBM)	Exercise-based multidisciplinary inpatient course	–	3 weeks	0	0	0	13/19
Arnadottir et al. [41]	1 group	7 sporadic IBM (chronic)	Home exercise programme (strength and mobility exercises and 15 min walk)	–	12 weeks	1	3	2	12/19
Chung et al. [42]	RCT	37 PM, DM (chronic) (22 PM/15 DM)	Home exercise programme (strength and mobility exercises and 15 min walk) and oral creatine supplements	Home exercise programme and placebo	6 months	2	3	0	24/28
Johnson et al. [45]	1 group	7 sporadic IBM (chronic)	Home exercise programme (functional exercise programme and aerobic training)	–	12 weeks	3	3	0	12/19
Munters et al. [35]	RCT	21 PM, DM (chronic) (9 PM/12 DM)	Supervised exercise programme (cycling and muscular endurance)	Non-intervention group	12 weeks	4	4	0	22/28
Alexanderson et al. [37]	RCT	19 PM, DM (acute) (10 PM/9 DM)	Home exercise programme (resistive exercise programme and brisk walking)	Range of motion exercise programme	24 weeks	2	3	2	21/28
Resistance only									
Spector et al. [47]	1 group	5 sporadic IBM (chronic)	Supervised exercise programme (progressive resistive training)	–	12 weeks	4	4	0	12/19
Varju et al. [48]	1 group	21 PM, DM Acute: 4 PM/6 DM Chronic: 5 PM/6 DM	Supervised exercise programme (bending and stretching exercise, isotonic muscle training and respiratory training)	–	3 weeks	2	4	0	14/19
Alexanderson et al. [38]	1 group	9 PM, DM (chronic) (4 PM/5 DM)	Supervised exercise programme (intensive muscular training)	–	7 weeks	4	4	1	15/19

Table 2 continued

Study	Design	N and diagnosis	Type of intervention	Control	Length	TP	FITT rep	FITT adh	D & B
Johnson et al. [46]	1 group	7 sporadic IBM (chronic)	Home exercise programme (functional exercise programme)	–	16 weeks	4	2	2	12/19
Aerobic only									
Wiesinger et al. [49]	RCT	14 PM, DM (chronic) (4 PM/10 DM)	Supervised exercise programme (cycling and step aerobic)	No training	6 weeks	4	4	0	22/28
Wiesinger et al. [50]	CT	8 PM, DM (chronic)	Supervised exercise programme (cycling and step aerobic)	No training	6 months	4	4	0	19/28

adh Reported in the result section; *CT* controlled trial; *DM* dermatomyositis; *FITT* frequency, intensity, time, and type; *D & B* Downs and Black checklist; *IBM* inclusion body myositis; *PM* polymyositis; *RCT* randomised controlled trial; *TP* training principles; *rep* reported in the "Methods" section

Table 3 Applications of the exercise training principles

Study	Sp	Pr	Ov	IV	Rev	DR
Aerobic and resistance						
Alexanderson et al. [40]	+	NR	NR	+	NR	NR
Alexanderson et al. [39]	+	+	NR	+	NR	NR
Heikkilà et al. [44]	?	?	NR	?	NR	NR
Arnadottir et al. [41]	+	NR	NR	?	NR	NR
Chung et al. [42]	+	NR	NR	+	NR	NR
Johnson et al. [45]	+	+	?	+	NR	NR
Munters et al. [35]	+	?	+	+	?	?
Alexanderson et al. [37]	+	NR	?	+	?	?
Resistance only						
Spector et al. [47]	+	+	+	+	NR	NR
Varju et al. [48]	+	?	+	?	NR	NR
Alexanderson et al. [38]	+	+	+	+	NR	NR
Johnson et al. [46]	+	+	+	+	NR	NR
Aerobic only						
Wiesinger et al. [49]	+	+	+	+	NR	NR
Wiesinger et al. [50]	+	+	+	+	NR	NR

+: reported, NR: not reported, ?: unclearly or inconsistently reported

varied between poor (kappa 0.05, external validity) to very good (kappa 0.80, confounding).

Discussion

The results of this review demonstrated that application of training principles and methodological quality were both reported inconsistently in those papers studied, whilst FITT components were reported more consistently in training prescriptions than in result sections. Eighty per cent of studies applied at least three out of four FITT components in their exercise prescriptions. However, none of the studies provided complete accounts of the level of adherence to the PE protocol. Sixty-four per cent of the studies provided no details on adherence to their training protocol.

Regarding IM patients, there were only three RCTs comparing a PE intervention with a non-exercising control group. The majority of the published studies were performed as a one-group design. Furthermore, the sample sizes of the included studies were low and varied between five and 37 patients, whereas half of the studies included 10 or less participants. In addition, the involved studies investigated different subcategories of IM (chronic or recent

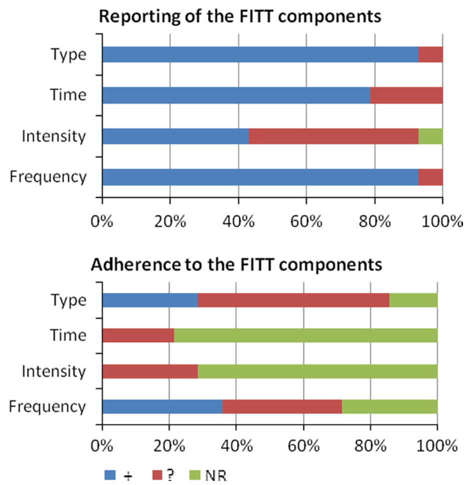


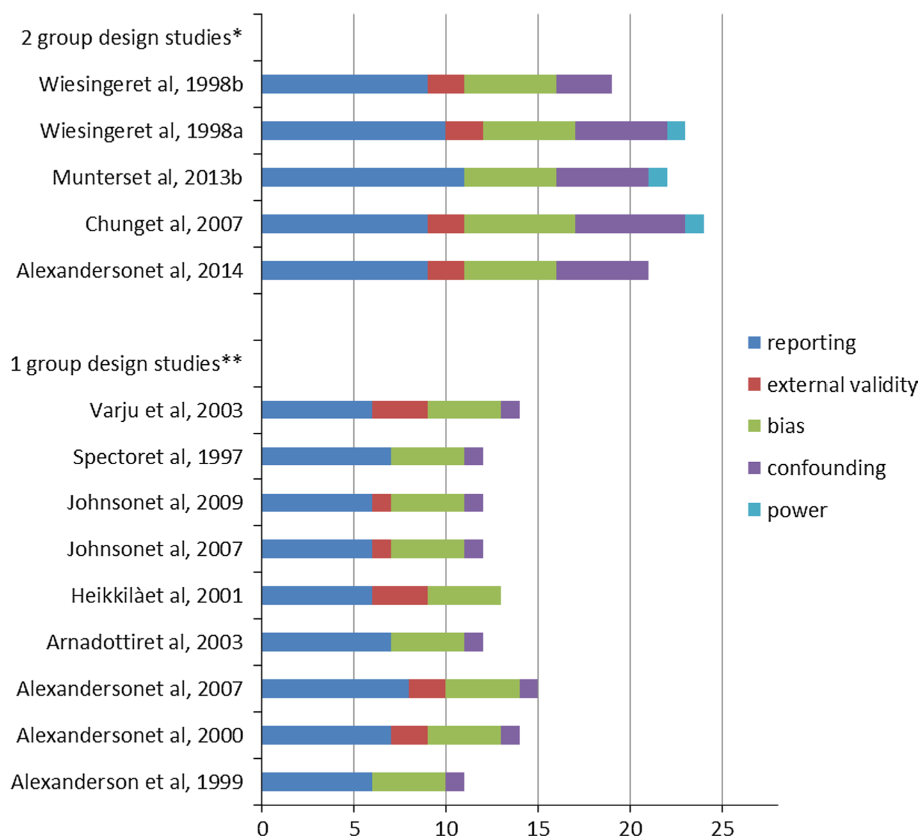
Fig. 2 Reporting of the planned exercise prescription components. (+) The percentage of studies that reported the component of exercise prescription. (?) The percentage of studies that was unclear or inconsistently with their reporting of the exercise prescription. (NR) The percentage of studies that did not report the component of the exercise prescription

onset) and different types of intervention. Taken together, the evidence for PE in IM is still weak and it is not yet known which training prescription is the most effective. Therefore, no final conclusion regarding the evidence for PE in IM patients can be drawn. These facts are indicative of the still sparsely investigated topic of exercise interventions for patients with inflammatory disease [18, 19].

Application of the principles of exercise training

Specificity was the most commonly applied training principle. Ninety-three per cent of the reviewed trials matched the training mode with their primary outcome measure. This result is in agreement with previous studies about the application of principles of PE training in cancer [20, 21] and stroke [22] survivors. Although lower values (89 and 64 %, respectively) were reported in cancer and stroke survivors, *specificity* was the most applied exercise training principle. In our review, only one study [44], assessing an exercise-based multidisciplinary inpatient course, did not report *specificity*. In this study, PE was a single part of a comprehensive rehabilitation programme and each participant performed different components of exercise. In contrast, *progression* and *overload* were reported in only 50 % of the included studies. Other authors found comparable values for the principle *progression* (41, 26, and 76 %, respectively) and lower values for the principle *overload* (31, 37, and 49 %, respectively) [20–22]. The principle of *overload* states that, to improve fitness, the intervention must be greater than what the individual is already doing (Table 1). Therefore, without knowing the baseline fitness levels of

Fig. 3 Methodological quality assessed with the Downs and Black checklist. *Maximal possible point score: 28. **Maximal possible point score: 19



studied individuals, it is impossible to determine whether adequate training intensities and volumes have been used. In studies evaluating resistance training, a valid and feasible way to assess baseline value is to perform a 1, 5, or 10 voluntary repetition maximum test for the target muscle groups [35, 38, 47] or to count the maximum number of times that participants were able to repeat the exercise in the initial assessment session [46, 48]. In studies investigating aerobic exercise, Vo_2 max [35] or maximum heart rate [49, 50] could be used to assess *initial value*. If the training matches the baseline level of the individual, improvement will occur. Thus, to assure continued improvement, the training intensity and/or volume must be adjusted after a certain period of training. *Progression* can be conducted in different ways. In order to maintain the same absolute training stimulus, the intensity or volume of an exercise must be increased continuously. Muscular strength training in IM patients can be modulated by increasing the level of resistance or the number of exercises, repetitions or sets [38, 45–47]. In cycle training, the resistance can be increased [49, 50]. The principle of *initial value* was considered in 79 % of the included studies. This rate is higher compared to studies including cancer [20–22] and stroke patients [26]. One reason for this difference could be that our reviewed studies included patients with muscular diseases. These patients have by definition impaired muscle function [9] and therefore a low *initial value* in muscle strength. This allows greatest room for improvement. *Reversibility* and *diminishing return* can only be judged in studies that investigate a follow-up after conclusion of the initial intervention. The two studies [35, 37] which performed a follow-up after the end of the intervention did not report whether the patients continued, stopped, or decreased with the PE programme. For that reason, both principles could not be judged unambiguously.

An explicit conclusion concerning efficacy of a specific exercise programme can only be drawn if at least the first four principles (*specificity, progression, overload, initial value*) are clearly stated. Otherwise it is not possible to distinguish if exercise training per se is not indicated or if the prescribed exercise programme was inadequate or under dosed. Lack of attention to these principles may affect the study impact and effect of exercise training may thus be underestimated. To investigate long-term effect, the two principles of reversibility and diminishing return need to be included in PE studies. Knowing that exercise has no depot effect [25], it would be important to study how patients can be motivated to continue exercise training after study conclusion.

Reporting of the prescription of the physical exercise training and adherence

Whilst only one paper [44] failed to report frequency and type of exercise prescribed, eight out of 14 reports did not adequately report the complete FITT components. Although intensity is a key component, it was the least reported one. If intensity is under a certain threshold, patients will probably not benefit from their training effort. Conversely, if the PE intensity is too high, patients' safety could be impaired. Due to the lack of equipment, it is not always feasible to measure intensity in absolute values, e.g. maximal oxygen consumption or measurement units such as watt, newton, or maximum peak torque. Nevertheless, intensity can always be described in a relative way. For resistance training, a 1, 5, or 10 repetition maximum can be tested. Then percentages of these results can be taken for the desired training intensity. For aerobic exercise, the percentage of the theoretical maximum heart rate could be used. Furthermore, a subjective way to measure intensity is the Borg's Rating of Perceived Exertion and Pain (RPE) Scales [52]. This scale values range from 6 to 20, where 6 is a very, very light and 20 a very, very hard exertion. This scale is an affordable, practical, and valid tool to monitor and prescribe exercise intensity. Exercise at an RPE of 11–13 (low) may be recommended for less trained individuals, whilst a RPE of 13–15 may be recommended where training should be more intense whilst still retaining an aerobic training effect [53].

Whilst reporting the PE training prescription is important, it is also necessary to identify which patients actually undertook PE and persisted with it. Only if adherence to the FITT components is completely covered and reported will the actual performed PE training be evident and thus conclusions for further research or practice be more safely drawn. To start and maintain an exercise programme is a huge challenge, particularly for inactive persons [54]. Therefore, it is important to know which PE training programme participants actually perform and how often they have performed it. If participants do not exercise regularly, the training goal may not be achieved. Additionally, it is important to know if participants had to modify their programme, for example because they were unable to perform the original planned intensity or training period. Therefore, besides information on frequency and type of exercise, additional information about intensity and time needed to perform the exercises is fundamental. Unfortunately, none of our included studies reported this information in sufficient detail. The poor reporting of adherence seems to be a common weakness in PE studies. This was also highlighted in studies with other diseases [20–22]. It is a challenge to control and verify adherence, especially in home-based training programmes. Patients could be motivated to fill out training logs and to send them back regularly. As known from questionnaires relating to physical activity, people tend to give socially desirable answers [55]. This risk also exists in diaries, as people may overestimate the level of performed exercises. One possibility for overcoming this shortcoming could be an e-health home-based training programme, using telecommunication technologies [56]. Such a programme would allow patients to report their performed exercise volume, intensity and perceived exertion immediately. Based on this information they receive direct feedback and their training programme could be adapted regularly. The training volume and intensity would be transparent and rehabilitation specialists would be able to react immediately if some patients did not adhere to the PE programme. In a recently published study investigating independent living, older adults showed that adoption of assistive technology devices for physical intervention tends to motivate and retain exercising for longer periods of time [57].

Methodological quality

One of the most prevalent methodological shortcomings was the insufficient power of the studies, only two of which reported how sample size was determined a priori. In the subscale **internal validity-confounding**, the items concerning the different intervention groups (four out of five items) could not be scored for those studies which had a one-group design. Because controlling for extraneous variables is not possible in studies with only one group, these are susceptible to confounding and tend to exaggerate the beneficial effects of interventions [58].

The item “lost to follow-up” was scored positive in 86 % of all studies. Compared with other exercise studies, attrition bias is not so prevalent in our review. This may be because the intervention durations of our studies were rather short and study samples small. This makes it easier to support and motivate individual participants. A common problem in the subscale **internal validity-bias** in studies with exercise interventions is the blinding of the participants and the reliability of compliance reporting. It is almost impossible to blind participants regarding an exercise intervention [59]. Only one RCT was able to blind its participants, and this was because it compared exercise training in combination with oral creating supplements with exercise training in combination with placebo. The subscale **external validity** is scored between 4 and 8 points. Although external validity is important for ascertaining implications for clinical practice, most checklists in fact ignore this aspect. To date, the best way to assess external validity is still unknown [29]. In the subscale **reporting**, the “description of the intervention” and “actual probability value” are the weakest scored items. The methodological quality of future studies may be improved if authors provide all of the information requested by the Risk of Bias checklist for RCTs [60] or the Downs and Black checklist [29] for non-randomised studies.

Strength and limitations

Although the intervention is the essence of each experimental study, its detailed description is often neglected in those trials evaluating the effect of PE training. Poor reporting of the intervention may bias the study outcomes in a way which is comparable to poor reporting of the methodological quality [24]. The strength of our study is that we evaluated the quality of the reporting and performing of the intervention as well as the methodological quality. Furthermore, we used a comprehensive search strategy in standard bibliographic databases to identify potential studies. Nevertheless, some limitations remain. Firstly, as we had to include studies with different study designs, nine out of 14 studies had no control group. Therefore, the risk of selection bias and confounding is greater than in a review of RCTs [58]. To address these limitations, we used a comprehensive quality checklist which deals with randomised and non-randomised studies. Secondly, we included different subtypes and phases of myositis. Thus, the included participants were very heterogeneous and training modalities could not be compared between the included studies. As a result, it was not possible to perform a meta-analysis. Thirdly, we could only judge the information authors described in their published articles. Hence, it is possible that some studies considered the principles of PE but did not report it. Such studies would thus be underrated in our review.

Fourthly, we did not focus on the outcome measures of the included studies. All studies reported aerobic capacity, aerobic endurance, or muscle strength as a primary outcome measurement. As reported in a previous review, both aerobic and strength training seems to have a beneficial effect on strength and endurance [23]. Additionally, all included studies evaluated laboratory measurement such as erythrocyte sedimentation rate, C-reactive protein or creatinine phosphokinase and/or inflammatory cell infiltrates. None of the reports found an aggravation of these muscle enzymes or of the inflammatory cell infiltrates.

Finally, we were unable to determine whether applying the exercise training principles explicitly influenced outcomes. Our studies were heterogeneous concerning design, sample size, and methodological quality. This means that too many factors had the potential to influence the outcome of the study. Thus, no conclusion could be drawn regarding the impact of the application of principles of exercise training on outcome.

Call for transparency to facilitate evidence-based practice

The steadily growing health market calls for effectively and efficiently performed PE interventions. Therefore, it is important that the goals for PE training are reasonable and attainable [25]. Whilst fitness levels of patients vary widely, these aims are best achieved with a custom-made and individually tailored training programme, with parameters that can be adjusted from workout to workout. These parameters include type, volume, intensity, and order of physical exercise as well as the frequency and length of training and the length of rest periods [25]. To achieve the desired training effect, PE programmes should consider the training principles [25] and the training parameters should be reported, e.g. by use of FITT components [26]. Only with a complete description of the PE strategy can clinicians reliably implement interventions that are effective. Furthermore, investigators can replicate or further develop research findings. To improve the completeness of reporting, and ultimately improve replicability of exercise interventions with IM patients, the Template for Intervention Description and Replication (TIDieR) checklist and guide might proof useful [24]. Using this checklist in conjunction with the CONSORT checklist [27] makes it easier for authors to structure description of their interventions, for reviewers and editors to assess the descriptions, and for clinicians to replicate the interventions. Thus, future methodological well-designed RCTs, including a detailed prescription of the physical exercise intervention, should be designed and evaluated in patients with IM.

Conclusion

This review showed that exercise training principles and FITT components in intervention studies for myositis patients were not systematically reported. When failing to apply the training principles, exercise interventions may be of insufficient intensity or may be executed under suboptimal circumstances. As a result, the effect of the physical exercise intervention may be underestimated and time allotted for therapy is not used effectively and efficiently. Furthermore, if the FITT components of physical exercise training and the adherence to these components are not explicitly reported, the intervention is not reproducible and it is difficult to transfer the results to the clinical setting. Therefore, future studies should consider the Template for Intervention Description and Replication checklist and guide in order to describe the training principles and report FITT prescriptions and, thus, allow development of replicable exercise recommendations for IM patients.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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