Effect of low-intensity aerobic cycling ergometer on ability to perform activity of daily living of patients with myasthenia gravis in RSUD Dr. Soetomo Surabaya

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Effect of Low-intensity aerobic cycling ergometer on ability to perform activity of daily living of patients with myasthenia gravis in RSUD Dr. Soetomo Surabaya

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ABSTRACT

Background and objectives. Myasthenia gravis (MG) is an autoimmune disease of the neuromuscular junction causing fluctuating skeletal muscle weakness and fatigue that result in increased restrictions on physical activity, affecting the patient's ability to perform daily activities in the family, social, and work environment. The MG-ADL scale is an assessment of the ability of the daily activities of MG patients that does not require equipment or special skills for the examiner and can be done in a short time. This study analyzes the effect of low intensity aerobic exercise cycle ergometer on the ability to perform daily activities of MG patients.

Materials and methods. Twenty-two MG patients, MGFA class IIa and IIb, aged 18–59, participated in this study. The subjects were randomly divided into an treatment group and a control group. The treatment group received aerobic cycle ergometer exercise for 30 minutes, three times per week, for eight weeks. Both groups were educated to continue medication from neurology, perform physical activity as usual, and breathing exercises. Assessment of MG-ADL performed before and after intervention.

Results. There was an improvement in scores on breathing and lower limb function in the treatment group. There was significant decrease in MG-ADL scores at the intervention group ($p = 0.000$) with large effect size (1.09). The comparison of MG-ADL scores between groups showed a significant value ($p = 0.009$) with a large effect size (1.24).

Conclusion. Low intensity aerobic exercise cycle ergometer for 8 weeks improves the ability to perform ADL in MG patient.

Keywords: Aerobic exercise, cycle ergometer, myasthenia gravis, activity of daily living, neuromuscular disease.

Abbreviations: Myasthenia gravis (MG), Neuromuscular Junction (NMJ), Acetylcholine receptor (AchR), Activity of Daily Living (ADL), The Myasthenia Gravis–Activities of Daily Living scale (MG-ADL), Montreal Cognitive Assessment Indonesia Version (MoCA-INA), Joint National Committee (JNC), New York Heart Association (NYHA), Body Mass Index (BMI), Wong Baker Faces Scale (WBFS), Myasthenia Gravis Foundation of America (MGFA), International Physical Activity Questionnaire (IPAQ),

INTRODUCTION

Myasthenia gravis (MG) is an autoimmune disorder affecting the neuromuscular junction, where antibodies target components of the postsynaptic membrane. This disrupts the transmission of signals from nerves to muscles, leading to weakness and fatigue in skeletal muscles[1]. The severity of MG varies among patients, with more severe cases posing a higher risk of myasthenic crisis—a critical condition marked by generalized muscle weakness and respiratory compromise that necessitates ventilatory support.[2].

The incidence of MG has risen globally over the last seventy years. Initially rare, with an estimated prevalence of 1 in 200,000 during 1915-1934, the discovery of anticholinesterase drugs in 1934 and acetylcholine receptor antibodies in 1969 contributed to increased recognition, leading to a prevalence of approximately 1 in 17,000

[3]. Advances in diagnosis, treatment, and intensive care have further reduced mortality rates among MG patients.[4]. Common symptoms include fluctuating muscle weakness and fatigue that worsen with activity and improve with rest. These symptoms significantly limit physical activity and social participation, often leading patients to adopt a sedentary lifestyle. This can severely impact daily activities within family, social, and occupational settings [5–8]. While fatigue in MG patients correlates with their ability to perform daily activities, studies have not found significant correlations between fatigue and walking ability, nor between functional capacity and overall quality of life in these individuals.[9–11].

Activities of Daily Living (ADL) refer to essential skills and tasks necessary for independent self-care, performed daily to fulfill one's role in family and society [12]. Research by Muppidi (2012), involving 156 patients with Myasthenia Gravis (MG), demonstrated a decline in their ability to perform daily activities on average [13]. Assessing ADL is crucial to determine the level of dependence and required assistance in daily life, often quantitatively evaluated using scoring systems [12]. The Myasthenia Gravis–Activities of Daily Living scale (MG-ADL), developed by Wolfe (1999), assesses symptom status and activity capability in MG patients, emphasizing functional impacts like grooming and oral hygiene rather than muscle strength [13]. This scale is simple, requiring no special equipment or training for examiners and can be swiftly administered. It serves as a metric reflecting MG severity [13,14]

Physical exercise, beneficial for both healthy individuals and those with chronic diseases, is recommended as part of MG management, although specific guidance is lacking [15]. Recent studies suggest that MG patients with mild disease activity can safely engage in exercise, including resistance and aerobic training [16]. Among aerobic exercises, cycle ergometer exercise is deemed safer due to its stationary nature, controlled environment, and ability to monitor vital signs easily, potentially minimizing injury risks. Aerobic exercise in MG is a safe non-pharmacological intervention yielding physiological benefits across multiple organ systems [17]. It enhances cardiac output, respiratory function, muscle endurance, and metabolic rate, potentially improving neuromuscular junctions and motor units [18,19].

Research on exercise effects in MG, particularly aerobic cycling's impact on ADL, remains limited, and consensus guidelines on physical exercise in MG are lacking. This study aims to analyze the effects of aerobic cycle ergometer training on ADL in MG patients at Dr. RSUD. Soetomo Surabaya.

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MATERIALS AND METHODS

This study employed a randomized controlled trial with a pre-test and post-test group design, conducted at the Medical Rehabilitation Outpatient Clinic of RSUD Dr. Soetomo, Surabaya, Indonesia, spanning from April to June 2023. Ethical clearance was granted by the Hospital Ethical Committee under clearance number 0601/KEPK/II/2023.

The study included 23 patients with Myasthenia Gravis (MG) selected through consecutive sampling. Inclusion criteria were: 1) confirmed MG patients classified as class I - IIb according to MGFA, 2) aged 18-59 years, 3) normal cognitive function (MoCA-INA Score ≥ 26), 4) receiving MG treatment at RSUD Dr. Soetomo and approved by a neurologist to participate, 5) capable of performing low-intensity aerobic exercise using a cycle ergometer for 30 minutes, 6) willing to participate and provide informed consent. Exclusion criteria were specified as follows: 1) MG crisis, 2) currently undergoing routine aerobic exercise 2-3 times per week in the last month, 3) pyridostigmine medication exceeding 5x60 mg/day, 4) history of cardiorespiratory diseases or uncontrolled systemic conditions, 5) pregnancy, 6) BMI ≥ 30 (obesity grade II), 7) balance disorders, 8) dependence on walking aids, 9) significant lower limb pain (WBFS > 4), and 10) neuromusculoskeletal or vascular lower limb diseases hindering ambulation.

Subjects who met the dropout criteria—such as unwillingness to continue, inability to complete exercises consecutively, illness, death, or discovery of new health conditions—were excluded from the study. Simple randomization was used to allocate subjects into either the treatment group (n=11) or control group (n=12).

The treatment group underwent low-intensity aerobic exercise using a cycle ergometer, received education on lifestyle adjustments, and learned effective breathing techniques. The intervention comprised three sessions per week over 8 weeks, with each session lasting 30 minutes (including a 5-minute warm-up, 20-minute core exercise, and 5-minute cool-down). Exercise intensity was monitored using the Target Heart Rate (Heart Rate Rest + 30% Heart Rate Rest) aiming for an activity level of 11 – 12 on the BORG scale.

Both groups were advised to continue neurological medication, maintain usual physical activity, and perform prescribed breathing exercises. MG-ADL scores were assessed before and after the 8-week intervention period in both groups. Data analysis was conducted using SPSS version 26, with paired *t*-tests used to compare MG-ADL scores within each group before and after the intervention, and independent *t*-tests used to compare scores between the two groups. A significance level of $p < 0.05$ was applied

RESULTS

At the end of the study, 22 subjects were analyzed. One subject dropped out of the control group at week 4 for personal reasons. All subjects were able to continue until the end of the study. The subjects consisting of 27.3% (6 people) male and 72.7% (16 people) female. During the 8 weeks of research, the total session of exercise that had to be done was 24 session, the 11 subjects in treatment group completed an average of 23.8 (99.1%) session during the study. Two subjects missed one training session each for non-medical reasons. The exercises given can be tolerated by the subject. There were no exacerbations in the intervention group during the study period. No cardiac, respiratory or musculoskeletal symptoms occurred during exercise.

The mean age of the research subjects was 46.27 ± 7.4 with an age range of 33-55 years. The mean age of onset was 37.36 ± 7.5 with an age range of 30-52 years, which was dominated by early onset MG at 95.4% (21 people). All subjects in this study were general MG type (100%). Based on the Myasthenia Gravis Foundation of America (MGFA) classification, all research subjects were class 2 MG type, consisting of 18.2% (4 people) in class 2a and 81.8% (18 people) in class 2b. The comorbidity of research subjects was hypertension, 18.2% (2 people), in the control group and 36.3% (4 people) in the intervention group and dominated by subjects without comorbidities, respectively 45.5% (5 people) in intervention group and 72.7% (8 people) in the control group. The characteristic of subject is shown in table 1.

Table 1 Characteristic of Subject

Profile	Item	Group		
		Treatment (n=11)	Control (n=11)	p^a
Sex (n (%))	Male	3 (27.3)	3 (27.3)	
	Female	8 (72.7)	8 (72.7)	
Age (mean ± SD)		46.27 ± 7.4	46.00 ± 6.5	0.58
BMI (mean ± SD)		21.91 ± 3.80	22.73 ± 3.87	0.83
	Underweight	1 (9.09)	1 (9.09)	
	Normal	5 (45.45)	6 (54.54)	
	Overweight	2 (18.18)	2 (18.18)	
	Obese grade I	3 (27.27)	2 (18.18)	
	Obese grade II	0 (0)	0 (0)	
Age of onset (mean ± SD)	Early onset (0-49 years old) (n (%))	37.36 ± 7.5 10 (90.9)	37.64 ± 4.9 11 (100)	0.14
	Late onset (≥ 50 years old) (n (%))	1 (9.1)	0 (0)	
Type of MG (n (%))	Ocular	0 (0)	0 (0)	
	General	11(100)	11 (100)	

MGFA Classification (n (%))	Class IIa	2 (18.2)	2 (18.2)	
	Class IIb	9 (81.8)	9 (81.8)	
Duration of treatment (years) (mean ± SD)		9.18 ± 4.37	7.09 ± 3.93	0.54
Dose of Pyridostigmine (60 mg/day) (n (%))	1 (60 mg)	3 (27.27)	1 (9.09)	
	2 (120 mg)	1 (9.09)	2 (18.18)	
	3 (180 mg)	3 (27.27)	3 (27.27)	
	4 (240 mg)	1 (9.09)	4 (36.36)	
	5 (300 mg)	3 (27.27)	2 (18.18)	
Methylprednisolone	Yes	2 (18.8)	1 (9.09)	
	No	9 (81.8)	10 (90.9)	
Physical activity (minutes/week)		696.36 ± 116.72	691.36 ± 113.72	0.96
IPAQ (n (%))	Light	5 (45.5)	4 (36.3)	
	Moderate	6 (54.5)	7 (63.7)	
Comorbid (n (%))	Dyslipidemia	1 (9.1)	1 (9.1)	
	Hypertension	4 (36.3)	2 (18.2)	
	Nephrolithiasis	1 (9.1)	0 (0)	
	No Comorbid	5 (45.5)	8 (72.7)	
Occupation (n (%))	Pharmacist	1 (9.1)	0 (0)	
	Housewife	5 (45.5)	7 (63.63)	
	Driver	1 (9.1)	1 (9.1)	
	Accountant	1 (9.1)	0 (0)	
	Vegetable Seller	1 (9.1)	1 (9.1)	
	Teacher	1 (9.1)	0 (0)	
	Nurse	0 (0)	1(9.1)	
	Technician	0 (0)	1 (9.1)	
	Mechanic	1 (9.1)	0 (0)	

MG = Myasthenia Gravis, MGFA = *Myasthenia Gravis Foundation of America*, IPAQ = International Physical Activity Questionnaire, [a])Levene test for homogenity. *)Significant if $p < 0.05$

Measurement of the ability to carry out daily activities for myasthenia gravis was carried out at the beginning (pre-test) and at the end of the study (post-test). The MG-ADL assessment in this study consisted of 8 questionnaire items including 3 items of oropharyngeal function (speech, chewing and swallowing), 1 item of respiratory function (breathing), 2 items of extremity function (inability to brush teeth/comb hair and inability to get up from a chair) and 2 ocular function items (double vision and eyelid closure).
The paired t test showed a significant difference in MG-ADL before and after treatment in the intervention group with a large effect size. In the control group, there were no significant differences in MG-ADL before and after treatment. The independent t test showed a significant difference between the mean MG-ADL of the intervention group and the control group after treatment a large effect size. The results of the MG-ADL scores in both groups can be seen in tables 2 and 3.

Table 2 Paired t test result of MG-ADL score for both groups

Variable	Group	Min	Max	Mean ± SD	Delta$^{\alpha}$	p$^{\beta}$	Effect size$^{\#}$
MG-ADL	Treatment pre-test	5	11	7.27 ± 1.48	1.54	0.000*	1.09 (large)
	post-test	4	9	5.73 ± 1.34			
	Control pre-test	5	11	7.27 ± 1.55	-0.28	0.192	0.18 (small)
	post-test	5	11	7.55 ± 1.57			

α = delta of MG-ADL score at pre-test and post-test, β = paired t test, # = Cohen's D,

*p<0.05

Table 3 Independent t test result of MG-ADL score for both group (Post-test)

Variable	Group	Min	Max	Mean ± SD	Delta$^{\alpha}$	p$^{\beta}$	Effect size$^{\#}$
MG-ADL	Treatment	4	9	5.73 ± 1.34	-1.82	0.009*	1.24 (large)
	Control	5	11	7.55 ± 1.57			

α = delta of MG-ADL score of both groups, β = Independent t test, # = Cohen's D,

*p<0.05

Table 4 shows that in the intervention group, there was no change MG-ADL score of chewing, swallowing, inability to brush teeth/comb hair. Talking score in intermittent slurring/nasal speech worsened by 9.1%. Double vision and eyelid droop improved by 9.1%. Breathing and impairment of ability to arise from a chair showed greatly improvement. At the start of the study, 81.8% of subjects complained of shortness of breath with exertion which decreased to 36.4% at the end of the assessment. Moderate impairment of ability to arise from a chair with the help of an arm were 72.7% at pre intervention, decreasing to 27.3% at post intervention. The control group showed constant scores at pre and post intervention of talking, swallowing, inability to brush teeth/comb and double vision. Shortness of breath with exertion and drooped eyelids improved by 9.1%, while inability to get up from a chair (always using arms) worsened by 9.1%.

Table 4 MG-ADL score for each component

MG-ADL Score	Treatment		Control	
	Pre-test (n)	*Post-test* (n)	*Pre-test* (n)	*Post-test* (n)
Talking				

0 = normal 1 = Intermittent slurring/nasal speech 2 = Constant slurring/nasal speech 3 = Difficult to understand speech	27.3% (3) 63.6% (7) 9.1% (1) 0% (0)	18. 2% (2) 72.7% (8) 9.1% (1) 0% (0)	36.4% (4) 63.6% (7) 0% (0) 0% (0)	36.4% (4) 63.6% (7) 0% (0) 0% (0)
Chewing 0 = Normal 1 = Fatigue with solid food 2 = Fatigue with soft food 3 = Nasogastric tube	18.2% (2) 81.8% (9) 0% (0) 0% (0)	18.2% (2) 81.8% (9) 0% (0) 0% (0)	18.2% (2) 81.8% (9) 0% (0) 0% (0)	9.1% (1) 90.9% (10) 0% (0) 0% (0)
Swallowing 0 = Normal 1 = Rare episode of choking 2 = Frequent choking necessitating changes in diet 3 = Nasogastric tube	54.5% (6) 45.5% (5) 0% (0) 0% (0)	54.5% (6) 45.5% (5) 0% (0) 0% (0)	45.5% (5) 54.5% (6) 0% (0) 0% (0)	45.5% (5) 54.5% (6) 0% (0) 0% (0)
Breathing 0 = Normal 1 = Shortness of breath with exertion 2 = Shortness of breath at rest 3 = Ventilator dependent	9.1% (2) 81.8% (9) 0% (0) 0% (0)	63.6% (7) 36.4% (4) 0% (0) 0% (00	27.3% (3) 72.7% (8) 0% (0) 0% (0)	36.4% (4) 63.6% (7) 0% (0) 0% (0)
Impairment of ability to brush teeth or comb hair 0 = None 1 = Extra effort, but no rest periods needed 2 = Rest period needed 3 = Cannot do one of these function	27.3% (3) 72.7% (8) 0% (0) 0% (0)	27.3% (3) 72.7% (8) 0% (0) 0% (0)	18.2% (2) 81.8% (9) 0% (0) 0% (0)	18.2% (2) 81.8% (9) 0% (0) 0% (0)
Impairment of ability to arise from a chair 0 = None 1 = Mild, sometimes uses arm 2 = Moderate, always uses arms 3 = Severe, requires assistance	0% (0) 27.3% (3) 72.7% (8) 0% (0)	27.3% (3) 45.5% (5) 27.3% (3) 0% (0)	0% (0) 36.4% (4) 63.6% (7) 0% (0)	0% (0) 27.3% (3) 72.7% (8) 0% (0)
Double Vision 0 = None 1 = Occurs, but not daily 2 = Daily, but not constant 3 = Constant	54.5% (6) 45.5% (5) 0% (0) 0% (0)	63.6% (7) 36.4% (4) 0% (0) 0% (0)	36.4% (4) 54.5% (6) 9.1%% (1) 0% (0)	36.4% (4) 54.5% (6) 9.11% (1) 0% (0)
Eyelid droop 0 = None 1 = Occurs, but not daily 2 = Daily, but not constant 3 = Constant	9.1% (1) 54.5% (6)	18.2% (2) 45.5% (5) 27.3% (3) 9.1% (1)	0% (0) 54.5% (6) 36.4% (4) 9.1% (1)	0% (0) 63.6% (7) 27.3% (3) 9.1% (1)

27.3% (3)
9.1% (1)

DISCUSSION

The MG-ADL score is an assessment tool used to measure the impact of MG on the patient's ability to carry out daily activities and can describe the severity of MG. MG-ADL consists of a series of assessments of oropharyngeal function, breathing, extremities and ocular symptoms. A higher score indicates more severe symptoms [13]

The results of this study show a positive effect of providing low-intensity cycle ergometer aerobic training on the MG-ADL score of the intervention group (p = 0.000), while the control group did not experience a significant change (p = 0.192). The effect size value before and after giving the intervention was 1.09, indicating that giving cycle ergometer training had a large effect on improving MG-ADL scores. The results of this study are in accordance with several previous studies regarding aerobic exercise in MG-ADL. A study using the Randomize control trial method by Birnbaum (2021) on 43 stable general MG patients aged 29-70 years showed that the addition of aerobic exercise using a rowing ergometer for 40 minutes, 3x/week for a total of 12 weeks caused a decrease in MG-ADL scores [20]. Similar results were also found in a case report study conducted by Lucia (2007) on a woman with general MG showing that providing aerobic exercise using walking, cycling or swimming with low to moderate intensity for 10-60 minutes per session for 5 times a week showed increasing independence and ability to perform ADL [21]. Research conducted by Muppidi (2011) with outcomes in the form of MG-ADL and QMG stated that a strong correlation was obtained between the QMG severity score and the ADL score. This study provides an analysis that an improvement of 2 points on the MG-ADL scale indicates clinical improvement and has acceptable reliability [13].

Aerobic exercise in MG is considered a non-pharmacological intervention that is safe and has physiological benefits in several body organ systems [17]. The organs involved include the cardiovascular, respiratory, hematological, musculoskeletal, immune and neuroendocrine systems. These benefits are in accordance with the results of this study which showed improvements in respiratory and lower extremity function. This improvement can be obtained due to several factors with the following explanation.

Aerobic exercise in general can provide a variety of benefits to both healthy individuals and MG patients. Cycle ergometer exercise was chosen in this study because this exercise is an exercise that is classified as safer than other aerobic exercises. Some of the advantages include using a stable stationary bicycle, adjustable room temperature, making it easier to monitor vital signs during exercise so it is hoped that it can minimize the risk of injury [16]

The biggest concern for clinicians and MG patient in providing exercise is the exacerbation of symptoms such as fatigue that occurs immediately or over a longer period of time as a result of excessive exercise [22]. The most important thing in maintaining safety during exercise is patient education to increase understanding of the disease they are experiencing. Considerations regarding tolerance of daily activities need to be taken into account so that patient are not burdened by the physical exercise provided. Exercise is given gradually in increasing intensity and duration of activity. The recommended exercise program for MG is given in a short duration and uses light-moderate intensity [22,23]. This research is the first intervention research given to MG so the intensity chosen starts from low intensity with a duration of 30 minutes.

Aerobic exercise in MG is considered a safe and physiologically beneficial non-pharmacological intervention in several body organ systems. The organs involved include the cardiovascular, respiratory, hematological, musculoskeletal, immune and neuroendocrine systems. These benefits are in accordance with the results of this study which showed improvements in respiratory and lower extremity function [17]

Aerobic exercise will increase the oxygen transport system, namely the amount of oxygen inhaled and distributed to body tissues. The heart response due to aerobic exercise is an increase in cardiac output caused by an increase in stroke volume and heart rate which can reach around 95% of the maximum level [24]. An increase in maximum cardiac output which is the result of enlarging heart dimensions, increasing contractility, and increasing blood volume allows greater ventricular filling and as a result a larger stroke volume [25].

The effect of exercise on respiration will result in increased ventilation as a result of increased respiratory rate and tidal volume. Tidal volume can increase up to 60% of vital capacity. Increased ventilation will also be followed by an increase in the fraction of oxygen inhaled. In addition, there is a decrease in oxygen pressure. Both of these things result in increased diffusion of oxygen from the alveoli into the blood so that the oxygen content distributed to the tissues is also higher. Increased ventilation is directly proportional to the increase in the fraction of oxygen inhaled. On the other hand, the oxygen pressure in the vasculature is lower. These two things cause high oxygen diffusion from the alveoli into the blood so that the oxygen content distributed to the tissues is also higher [18]

Exercise causes vasodilation in the muscle vascular bed and vasoconstriction in areas that require lower metabolism as a form of compensatory mechanism. Large blood vessels will experience arteriogenesis (indicated by an increase in diameter), while capillary fibers will expand through angiogenesis. Arteriogenesis will increase peripheral vascular capacity, while angiogenesis brings blood closer to muscle cells and increases oxygen extraction. The function of the endothelium and smooth muscle fibers will also change, resulting in an increase in the functional ability of blood vessels to deliver blood [26].

The response of the chronic phase of skeletal muscle is an increase in anabolism resulting in protein balance and protein synthesis. Skeletal muscle adaptation to all phases takes the form of increased recruitment of type I muscle fibers which are slow twitch, more dominant than type II which are fast twitch, increasing muscle mass and strength [27]. Aerobic exercise can also change the proportions of muscle fibers. The percentage of type I muscle fibers that are resistant to fatigue, rich in mitochondria and have a greater number of capillaries compared to type II muscle fibers [28].

Exercise will also affect the lactate threshold. Lactate threshold is a limit at which anaerobic metabolism will be activated resulting in accumulation of lactate in tissues and blood. Exercise with an intensity above the lactate threshold generally does not last long and is difficult to tolerate because of increased fatigue. Lactate threshold occurs around 50-60% VO_2max. In individuals who are endurance trained, this lactate threshold can increase to 90% of VO_2max [26].

Aerobic exercise will cause activity to increase so that metabolic rate increases, especially in muscles, which will cause muscle fitness and endurance so that it will improve the number and quality of NMJ and motor units which influence muscle mass and strength [19].The comparison of total MG-ADL scores following low-intensity cycle ergometer aerobic exercise between the intervention and control groups revealed a statistically significant difference ($p = 0.009$). This indicates that administering this training can significantly reduce MG-ADL scores compared to not providing the training. These findings align with a previous study conducted by Misra (2021) [17], which was a randomized controlled trial involving mild to moderate MG patients. In that study, patients were randomized into two groups: one performing 30 minutes of walking alongside standard treatment, and the other resting. Results showed that patients in the walking group had improved quality of life, evidenced by higher MG-15 Quality of Life (MG-QOL15) scores. Moreover, the exercise group exhibited a 2-point decrease in MG-ADL scores and better performance in the 6-Minute Walk Test (6MWT) compared to the control group, with no significant adverse effects noted. The study concluded that regular walking can enhance quality of life and daily activity capabilities in patients with mild to moderate MG [17]

In this current study, light-intensity aerobic cycle ergometer training was provided without incorporating strength or balance exercises, aiming to mitigate the risk of exacerbating fatigue or triggering a myasthenic crisis in MG patients. However, this study has several limitations. Firstly, the nature of the intervention did not allow for blinding, as evaluations post-treatment were conducted by researchers themselves without masking, potentially introducing measurement bias. Secondly, the study's subjects were not fully representative of the broader MG population, as only patients with generalized MG and MGFA classifications IIa and IIb were included.

CONCLUSION

Low intensity aerobic exercise cycle ergometer for 8 weeks can improve ability to perform ADL in MG patient.

Conflicts of interest:

No potential conflict of interest relevant to this article was reported.

Author's contributions:

Conceptualization: IM, MA, YDP, PS. Data curation: IM, MA, YDP, PS. Methodology: IM, MA, YDP, PS, SM. Project administration: IM. Visualization: IM. Writing - original draft: IM. Writing - review and editing: IM, MA, YDP, PS, SM. All authors have read and approved the submitted manuscript. The manuscript has not been submitted elsewhere nor published elsewhere in whole or in part.

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REFERENCES

[1] Arpandy GA, Halim MS. Gambaran aspek kognitif dan kepribadian pasien Myasthenia Gravis (Studi dilakukan di Jabodetabek dan Jawa Timur). Jurnal Psikogenesis 2013;2:49–60. https://doi.org/https://doi.org/10.24854/jps.v2i1.41.

[2] Harjana LT, Hardiono H. Myasthenia Crisis Vs Cholinergic Crisis: Challenges in Crisis Management Without Plasmapheresis or Intravenous Immunoglobulin (IVIG). Indonesian Journal of Anesthesiology and Reanimation 2020;2:53–8. https://doi.org/10.20473/ijar.V2I22020.53-58.

[3] Dresser L, Wlodarski R, Rezania K, Soliven B. Myasthenia gravis: epidemiology, pathophysiology and clinical manifestations. J Clin Med 2021;10:2235. https://doi.org/10.3390/jcm10112235.

[4] Carr AS, Cardwell CR, McCarron PO, McConville J. A systematic review of population based epidemiological studies in Myasthenia Gravis. BMC Neurol 2010;10:1–9. https://doi.org/10.1186/1471-2377-10-46.

[5] Gilhus NE, Verschuuren JJGM, Hovland SIB, Simmonds H, Groot F, Palace J. Myasthenia gravis: do not forget the patient perspective. Neuromuscular Disorders 2021;31:1287–95. https://doi.org/10.1016/j.nmd.2021.07.396.

[6] Sadri Y, Haghi-Ashtiani B, Zamani B, Akhundi FH. Study of demographic, clinical, laboratory and electromyographic symptoms in Myasthenia Gravis patients referred to the neurology clinic of Rasoul Akram hospital in 2015. J Med Life 2015;8:218–21.

[7] Rahbek MA, Mikkelsen EE, Overgaard K, Vinge L, Andersen H, Dalgas U. Exercise in myasthenia gravis: A feasibility study of aerobic and resistance training. Muscle Nerve 2017;56:700–9. https://doi.org/10.1002/mus.25552.

[8] Farrugia ME, Di Marco M, Kersel D, Carmichael C. A Physical and Psychological Approach to Managing Fatigue in Myasthenia Gravis: A Pilot Study. J Neuromuscul Dis 2018;5:373–85. https://doi.org/10.3233/JND-170299.

[9] Kartika L, Subadi I, Pawana IPA, Andriana M, Sugianto P. Correlation of fatigue on walking ability in myasthenia gravis patients: a cross-sectional study. Annals of Medicine and Surgery 2024;86:115–20. https://doi.org/DOI: 10.1097/MS9.0000000000001508.

[10] Anggarini YD, Subadi I, Andriana M, Poerwandari D, Sugianto P, Kartika L, et al. The correlation between functional capacity and quality of life in patients with myasthenia gravis. Romanian JouRnal of NeuRology 2023;22:196. https://doi.org/DOI: 10.37897/RJN.2023.3.4.

[11] Permanasari A, Tinduh D, Wardhani IL, Subadi I, Sugianto P, Prawitri YD. Correlation between Fatigue and Ability to Perform Activities of Daily Living in Myasthenia Gravis Patients. Open Access Maced J Med Sci 2022;10:205–9. https://doi.org/https://doi.org/10.3889/oamjms.2022.8231.

[12] Sugiarto C, Sobaryati S, Sadeli HA, Murni TW. PERBANDINGAN DOSIS PIRIDOSTIGMIN, PERFORMA FUNGSIONAL, DAN DERAJAT KLINIS PASIEN MIASTENIA GRAVIS SEBELUM DAN SETELAH TIMEKTOMI. Majalah Kedokteran Neurosains Perhimpunan Dokter Spesialis Saraf Indonesia 2018;35. https://doi.org/10.52386/neurona.v35i4.23.

[13] Muppidi S. Outcome Measures in Myasthenia Gravis: Incorporation Into Clinical Practice. J Clin Neuromuscul Dis 2017;18:135–46. https://doi.org/10.1097/CND.0000000000000156.

[14] de Meel RHP, Raadsheer WF, van Zwet EW, Verschuuren JJGM, Tannemaat MR. Sensitivity of MG-ADL for generalized weakness in myasthenia gravis. Eur J Neurol 2019;26:947–50. https://doi.org/10.1111/ene.13867.

[15] O'Connor L, Westerberg E, Punga AR. Myasthenia Gravis and Physical Exercise: A Novel Paradigm. Front Neurol 2020;11. https://doi.org/10.3389/fneur.2020.00675.
[16] Kisan R, Kisan SR, OR A, SP C. Treadmill and Bicycle Ergometer Exercise: Cardiovascular Response Comparison. Glob J Med Res 2012:1–4.
[17] Misra S, Chaturvedi A, Misra NC. Management of gingivobuccal complex cancer. Ann R Coll Surg Engl 2008;90:546–53. https://doi.org/10.1308/003588408X301136.
[18] Wagner PD. The physiological basis of pulmonary gas exchange: implications for clinical interpretation of arterial blood gases. European Respiratory Journal 2015;45:227–43. https://doi.org/10.1183/09031936.00039214.
[19] Mohamed RA, Mohamed ESH, Basiouny MA, Hamoda IM, Hanoura ESM, Elhenedi EI, et al. Effect of Two Different Rehabilitation Approaches on Pulmonary Functional Tests, Neuromuscular Functions and Quality of Life in Juvenile Myasthenia Gravis: A Randomized Controlled Trial Study. Medicina (B Aires) 2022;58:374. https://doi.org/10.3390/medicina58030374.
[20] Birnbaum S, Porcher R, Portero P, Clair B, Demeret S, Eymard B, et al. Home-based exercise in autoimmune myasthenia gravis: a randomized controlled trial. Neuromuscular Disorders 2021;31:726–35. https://doi.org/https://doi.org/10.1016/j.nmd.2021.05.002.
[21] Lucia A, Maté-Muñoz JL, Pérez M, Foster C, Gutiérrez-Rivas E, Arenas J. Double trouble (McArdle's disease and myasthenia gravis): how can exercise help? Muscle Nerve 2007;35:125–8. https://doi.org/10.1002/mus.20645.
[22] Julia N, Hafer-Macko C, Foidel S. Exercise and myasthenia gravis: a review of the literature to promote safety, engagement, and functioning. Int J Neurorehabilitation Eng 2016;3:3. https://doi.org/10.4172/2376-0281.1000218.
[23] Cass S. Myasthenia gravis and sports participation. Curr Sports Med Rep 2013;12:18–21. https://doi.org/10.1249/JSR.0b013e31827dc211.
[24] Polen ZK, Joshi S. Comparison of treadmill versus cycle ergometer training on functional exercise capacity in normal individuals. Int J Curr Res Rev 2014;6:61.
[25] Hellsten Y, Nyberg M. Cardiovascular adaptations to exercise training. Compr Physiol 2015;6:1–32. https://doi.org/10.1002/cphy.c140080.
[26] McConnell A. Respiratory muscle training: theory and practice. Elsevier Health Sciences; 2013.
[27] Farrell C, Turgeon DR. Normal versus chronic adaptations to aerobic exercise. StatPearls [Internet], StatPearls Publishing; 2023.
[28] Bogdanis GC. Effects of physical activity and inactivity on muscle fatigue. Front Physiol 2012;3 MAY:1–15. https://doi.org/10.3389/fphys.2012.00142.