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CASE REPORT

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Whole-body-electro-myostimulation for the care of inclusion body myositis—A case report

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Key Clinical Message

External muscle stimulation, possibly combined with active muscle contraction, could improve physical functioning and performance in inclusion body myositis.

Abstract

Inclusion body myositis (IBM) is a chronic, progressive inflammatory muscle disease with largely unknown causes. It typically affects men more than women, usually beginning in the latter half of life. IBM leads to muscle weakness and wasting, especially in the arms and legs, which significantly impairs daily functioning and complicates participation in exercise training. Few studies have examined the impact of physical training on fitness, inflammation markers, and quality of life in IBM patients. The patient, a Caucasian male (78.3 kg, 174.0 cm, born October 1948), was diagnosed with IBM in October 2011. From October 2017 to September 2019, he underwent exercise training focused on external muscle stimulation combined with active muscle contractions. Regular assessments included cardiopulmonary exercise testing, functional tests (6-min walking test, modified timed up and go test, modified chair rise test), lung function exams, blood parameters, body composition, and quality of life questionnaires. The decline in physical fitness may have been slowed during the intervention period, as indicated by some improvements like peak oxygen uptake and the functional test results while other parameters remained unchanged or declined like peak power output, fat-free mass or lung functioning. However, a recurrence of his prostate cancer after treatment with androgen deprivation therapy may have led to further declines and thus increased muscle wasting. The data may suggest that supportive exercise programs focusing on external muscle stimulation, possibly combined with active muscle contraction, might improve physical functioning, exercise performance, and quality of life in IBM management.

KEYWORDS

exercise training, inflammatory myopathy, muscle weakness, physical functioning, whole-body-electro-myostimulation

1 | INTRODUCTION

Inclusion body myositis (IBM) is a chronic progressive inflammatory muscle disease with largely unknown causes.[1] Typical symptoms include muscle weakness and atrophy, initially in the extremities, often followed by a loss of function in breathing and swallowing muscles.[2–4] The increasing muscle weakness accompanied by muscle atrophy significantly affects the ability to cope with activities of daily living and as the disease progresses, the ability to walk and grip is particularly limited.[1–6] Due to the progressive course, most patients have to resort to the use of walking aids or even become wheelchair-bound.[6] Treating IBM with medication is proving to be extremely difficult. Furthermore, malfunctions of the immune system have been described in IBM.[7–9] However, regardless of the involvement of immunological reactions in the pathogenesis of the disease, immunotherapeutic treatment approaches are currently ineffective.[8,9]

In contrast to conservative treatment options, physical training has been deliberately avoided in the past, under the assumption that heavy exertion or overload could lead to increased muscle breakdown and, thus, the progression of the disease.[10] However, physical inactivity may actually lead to a reduction in physical performance, leading to a further decline in muscle mass and strength, as well as endurance capacity, and consequently a loss of physical functionality.[11] First attempts have been made to scientifically prove that physical training in IBM could not only be safe, but also have a positive effect on physical performance.[10,12] Accordingly, physical training may help in maintaining or even improving endurance and strength performance and may counteract the loss of muscle mass and functionality in IBM patients.[12–17] However, due to limited physical capacity with disease progression, actively engaging in exercise is challenging. Consequently, there is a need for supportive exercise regimens that focus on external muscle stimulation possibly combined with active muscle contractions like whole-body-electromyostimulation (WB-EMS).

Whole-body-electro-myostimulation (WB-EMS) is a technology based on local EMS by stimulating up to nine (main) muscle groups at the same time, each with its own intensity by providing bipolar low frequency intensity of 80–85 Hz.[18] WB-EMS has been associated with increased lean and/or muscle mass in healthy untrained and trained populations[19] but also in cardiac patients and elderly diagnosed with sarcopenia as well as cancer patients.[20,21] However, despite beneficial effects WB-EMS has also been shown to induce high levels of creatine kinase (CK) in healthy individuals.[22,23] Moreover, participants discontinued training interventions due to "muscular discomfort" as reported by Stöllberger and Finsterer.[22] Elevated serum CK concentrations are a hallmark of IBM[7–9] and, thus, a further increase in CK levels caused by WB-EMS may be of concern for IBM patients due to an increased risk for acute renal failure or acid–base and electrolyte abnormalities.[24]

Since WB-EMS has been shown to be suitable external stimuli to induce positive muscle adaptations despite low active muscle activation, we hypothesized that WB-EMS can slow down physical deconditioning by eliciting adaptive muscle responses even in an advanced state of IBM with existing considerable muscle weakness, muscle atrophy and lack of motor control. Therefore, this case study aimed to evaluate the effects of WB-EMS on the physical functioning and the quality of life (QoL) in a 70-year-old male patient with severe IBM. Further, data on the feasibility and safety were collected.

2 | CASE REPORT

2.1 | Methods

2.1.1 | Subject

A 69-year-old man with severe IBM participated in this case study (see Table 1 for anthropometric data). Diagnosed at age 63 in October 2011 with progressive arm and leg weakness and multiple falls confirmed by microscopy and immunohistochemistry, he experienced significant mobility restrictions due to advanced muscle atrophy and dysfunction. Additionally, he had type 2 diabetes (since 2007), hypertension (since 2012), plasmacytoma (since 2009), and prostate cancer (diagnosed in 2009 with a complete prostatectomy and increased PSA in 2019).

The patient reported that performing physical movements required significant mental focus. Due to leg muscle degeneration, his gait was severely restricted. He could only climb stairs with assistance and needed an elevating cushion (15–20 cm) and an armrest to rise from a sitting position. Additionally, due to severe physical deterioration, the patient was not, or was just barely, able to execute strengthening exercises or strength-demanding movements with active voluntary contraction.

Initial medications included an angiotensin II receptor antagonist, a beta-blocker, a calcium antagonist, and insulin glargine. He received no specific IBM medication except for two immunoglobulin therapies in 2012 and 2015, which he discontinued of his own volition due to

an oncological disease. After a prostate carcinoma recurrence in 2019 with elevated PSA, he underwent androgen deprivation therapy (ADT), starting with three trenantone injections followed by bicalutamide.

The patient was under our care from October 2017 to September 2020. Initial examinations included blood samples, anthropometrics, and extensive physical functioning assessments, including endurance, strength, and functional tests (e.g., timed up and go test). The study complied with the Declaration of Helsinki and received ethical approval from the local university's Ethics Committee. The patient provided written informed consent before the first measurement and training. Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

2.1.2 | Time Line, measurements and exercise training

The patient reported to the laboratory at six time points as outlined in Figure 1.

2.1.3 | Blood parameter

Venous blood samples were collected 3 h after breakfast, with the patient abstaining from alcohol, caffeine, and vigorous activity the day before. A differential cell count was determined by fluorescent flow cytometry (Sysmex KX-21 N, Sysmex Corporation, Kobe, Japan).

In addition, neutrophil/lymphocyte ratio (NLR), platelet/lymphocyte ratio (PLR) and the systemic immune

TABLE 1 Patient anthropometrics throughout the study period.

	T1 Oct/2017	T2 Feb/2018	T3 May/2018	T4 Oct/2018	T5 Mar/2019	T6 Sep/2020
Anthropometry (Bioelectrical impendence analysis)						
Body weight (kg)	78.3	n.a.	79.3	77.2	80.8	79.7
Height (cm)	174.0	n.a.	173.7	174.3	173.7	173.2
BMI ($kg \cdot m^{-2}$)	25.9	n.a.	26.1	25.4	26.8	26.6
Body fat (kg)	36.0	n.a.	35.0	35.0	35.2	37.6
Body fat (%)	46.0	n.a.	44.2	45.3	43.5	47.2
Fat-free mass (kg)	42.3	n.a.	44.1	42.2	45.7	42.1
Fat-free mass (%)	54.0	n.a.	55.8	54.7	56.5	52.8
Left leg (kg)	3.03	n.a.	3.6	4.3	5.9	4.4
Right leg (kg)	3.09	n.a.	3.4	3.8	4.9	4.2
Hydration (%)	99.1	n.a.	99.5	108.2	113.1	118.1

Abbreviation: n.a, not assessed.

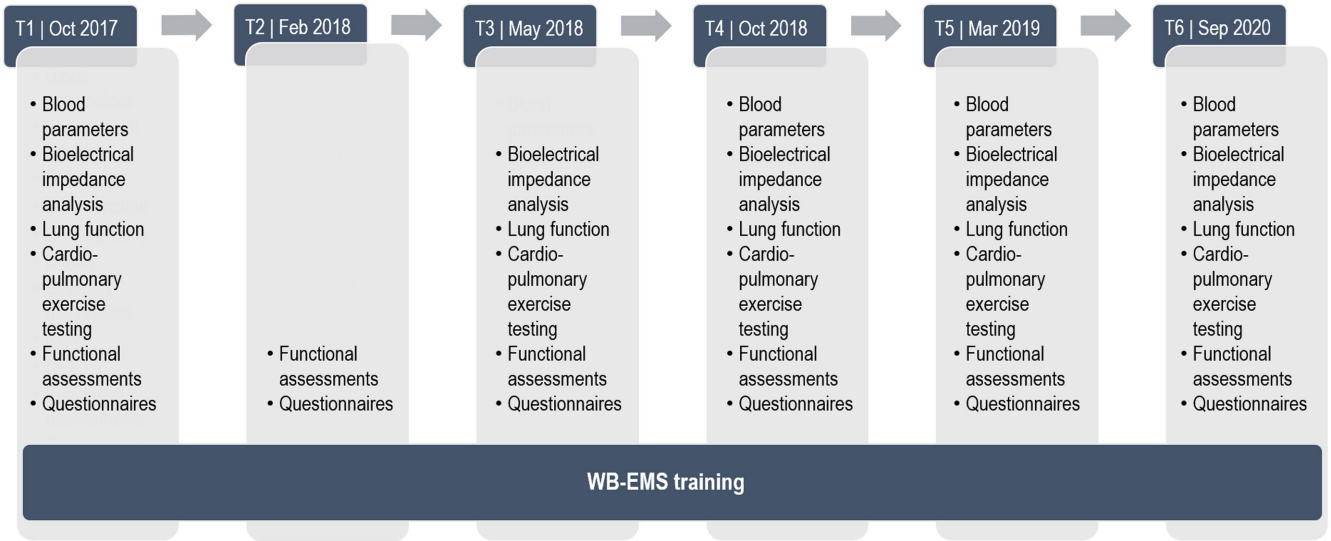

FIGURE 1 Time line of the case. BFR: Blood flow restriction; WB-EMS: Whole-body electromyostimulation.

inflammation index (SII, platelet counts x neutrophil counts/lymphocyte counts) were calculated. Although these markers have not yet been used in IBM patients, they are known from other clinical settings and may provide information on the inflammatory status.[25,26] Furthermore, CK, C—reactive protein and erythrocyte sedimentation rate was determined.

2.1.4 | Body composition

Body composition (total body weight in kg, fat- and fat-free mass in kg and percentage as well as hydration (ratio of extracellular to intracellular water)) was assessed by bioelectrical impendence analysis (BIA, seca medical Body Composition Analyzer (mBCA 515), seca GmbH & Co.KG., Hamburg, Germany), using two electrodes on the hands and feet. The body mass index (BMI) in $kg \cdot m^{-2}$ was calculated manually.

2.1.5 | Lung function

A spirometry (Easy on-Desk, ndd Medizintechnik AG, Zurich, Switzerland) was performed to determine the function of the lung and respiratory muscles by measuring forced vital capacity (FVC) and the forced expiratory volume in the first second of exhalation (FEV_1) both in liter.

2.1.6 | Cardiopulmonary exercise testing (CPET)

To assess peak oxygen uptake (VO_{2peak}) in $ml \cdot min^{-1} \cdot kg^{-1}$, the patient performed an incremental CPET on a cycle ergometer (Excalibur sport, Lode BV, Groningen, the Netherlands) according to a modified WHO protocol. The load started at 15 W and was increased by 15 W every 2 min until voluntary exhaustion. The patient was requested to maintain a pedaling frequency of 65 rpm throughout the test. Electrocardiography (ECG) was recorded before and constantly during the CPET and was reviewed by a cardiologist. Breathing gases were continuously recorded breath-by-breath using a gas exchange analyzer (ZAN600 CPET, nSpire Health GmbH, Oberthulba, Germany). Prior to the test, the device was calibrated for volume and fractional gas concentrations. In order to determine blood lactate concentrations in mmol per liter, 20 mL of capillary blood samples were collected from the earlobe within the last 15 s at the end of each increment (Biosen S-Line, EKF Diagnostics, Barleben, Germany). Heart rate (HR) was measured in beats per minute (bpm) using a commercially available wrist monitor and transmitter chest belt (Polar A300 Fitness/Activity Tracker, Polar Electro, Kempele, Finland). HR readouts were reported 10 s prior to the end of the increment and directly after volitional termination of the test. Furthermore, the patient was asked to rate the subjective perceived exertion (RPE) at the end of every increment on the Borg Scale. The patient was verbally encouraged to achieve maximal voluntary exhaustion and the test was stopped once the requested pedaling frequency was no longer maintained.

2.1.7 | Functional assessments

Functional assessments were conducted to simulate activities of daily living. As the patient already showed difficulties completing the functional assessments per protocol, we conducted a modified version of the chair rise test (CRTm) and a modified timed up and go test (TUGm). Additionally, a 6-min walking test (6MWT) was performed.

Using the CRTm, the time for the patient to stand up and sit down three times was measured in seconds. The patient started seated upright with feet hip-width apart and gaze straight ahead. Standing required fully extended legs, and sitting required contact with the seat and backrest. Timing ended after the third repetition when the patient touched the seat and backrest. The TUGm measured the time in seconds to get up from a chair, walk three meters, and sit down again, starting from the same position as the CRTm. The CRTm differed by having three repetitions instead of five. Modifications for both tests included allowing arm use and an elevated seat height of 65 cm instead of 43 cm. (Figure 2A).

For the 6MWT, the patient walked as far as possible over a 30-m distance in 6 min. Rest was allowed without stopping the clock. Two cones marked the track, which had to be circled on the outside. The patient walked without any aid or assistance. The score is defined by the total meters achieved.

2.1.8 | Questionnaire-assessed patient-reported outcomes

In order to assess disease-specific QoL, the inclusion body myositis functional rating scale (IBM-FRS)[27] and the short form (36)[28] health survey were used.

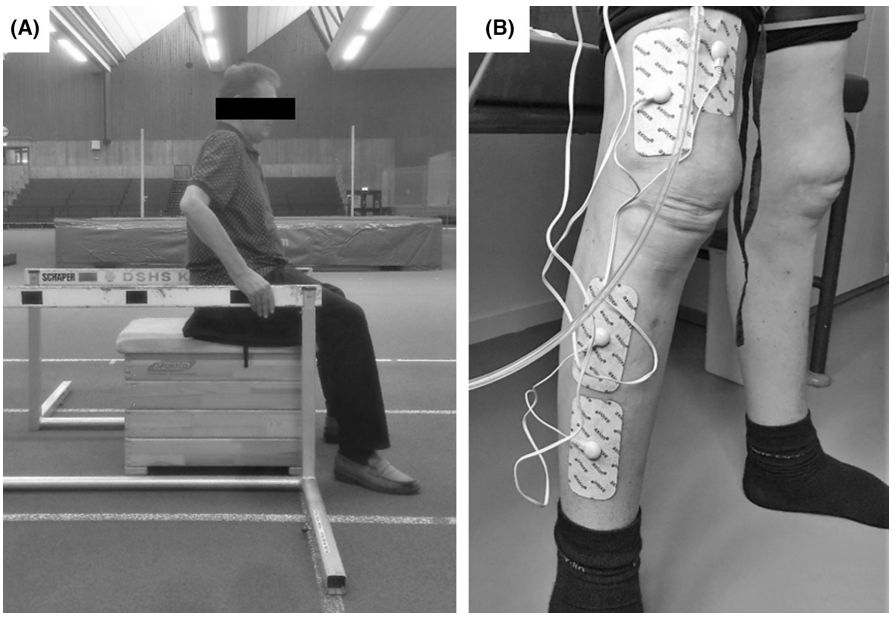

FIGURE 2 (A) Modified setup for the chair rise and timed up and go test allowing the patient to use the arm and using a higher seat height; (B) Placement of the additional electrodes to stimulate the distal part of the thigh and shin muscle.

2.1.9 | Exercise intervention

During the first two months, the patient performed the WB-EMS (miha bodytec, Augsburg, Germany) training twice a week to get a sufficient familiarization with the system and the stimulus. From December 2017 onwards, dynamic movements (e.g., the squat or shoulder press with resistance bands or dumbbells) were added to the WB-EMS while the training frequency remained at two sessions a week. The training regimen was based on a protocol which has been shown to be effective for enhancing strength and performance parameters in elite soccer players[19] while the intensity was adjusted. Biphasic rectangular wave pulsed currents (80 Hz) were used with an impulse width of 350 µs and the stimulation intensity (0–120 mA) was determined and set separately for each muscle group by using a RPE.[19] Overall intensity was recorded as the sum of the individual stimulation intensity values in mA per body region (legs, buttocks, lower back, upper back, rips, abdomen, chest, arms, and calves). Due to the strong mental focus during performing physical movements, the upper and lower body training were separated with two sets of 20-min per set. Since the WB-EMS suit did not reach the distal segments of the lower extremities, we used additional surface electrodes (100×50 mm; 3.5; axion GmbH, Leonberg, Germany) to stimulate the lower thigh and shin muscles (Figure 2B).

2.1.10 | Data analysis

The outcomes are presented as absolute and relative changes throughout the measurement time points. Figure 3 shows mean values ± standard deviation. Data analyses were performed using Microsoft Excel® 2013 (Microsoft, Redmond, WA).

3 | RESULTS

3.1 | Training adherence

Training adherence was 72.3%. The WB-EMS intensity was increased over time and reached a peak in March 2019 (Figure 3). From March 2019, the patient reduced the WB-EMS intensity with only minor adjustments afterwards after the recurrence of the prostate carcinoma (Figure 3).

3.2 | General condition, anthropometrics and physiological function

Patient characteristics are presented in Table 1.

Bodyweight, BMI, body fat and fat-free mass remained unaltered with small variations between +3.5 and −2.5%. However, fat-free mass of the left (T3: +18.8; T4: +41.9; T5: +94.7 and T6: 45.2%) and right (T3: +10.0; T4: +23.3; T5: +58.6 and T6: 35.9%) leg increased over time. Similarly, body hydration increased (T3: +0.4; T4: +9.1; T5: +14.0 and T6: +19.0%).

FVC and FEV_1 both decreased over time (Table 2). The Tiffeneau-Pinelli index dropped from T1 (86.5%) to T3 (75.0%) before rising again in T4 (86.1%), T5 (84.9%) and T6 (89.9%).

Blood parameter including basic blood count and inflammation markers basically all dropped from T1 to T4, T5 and

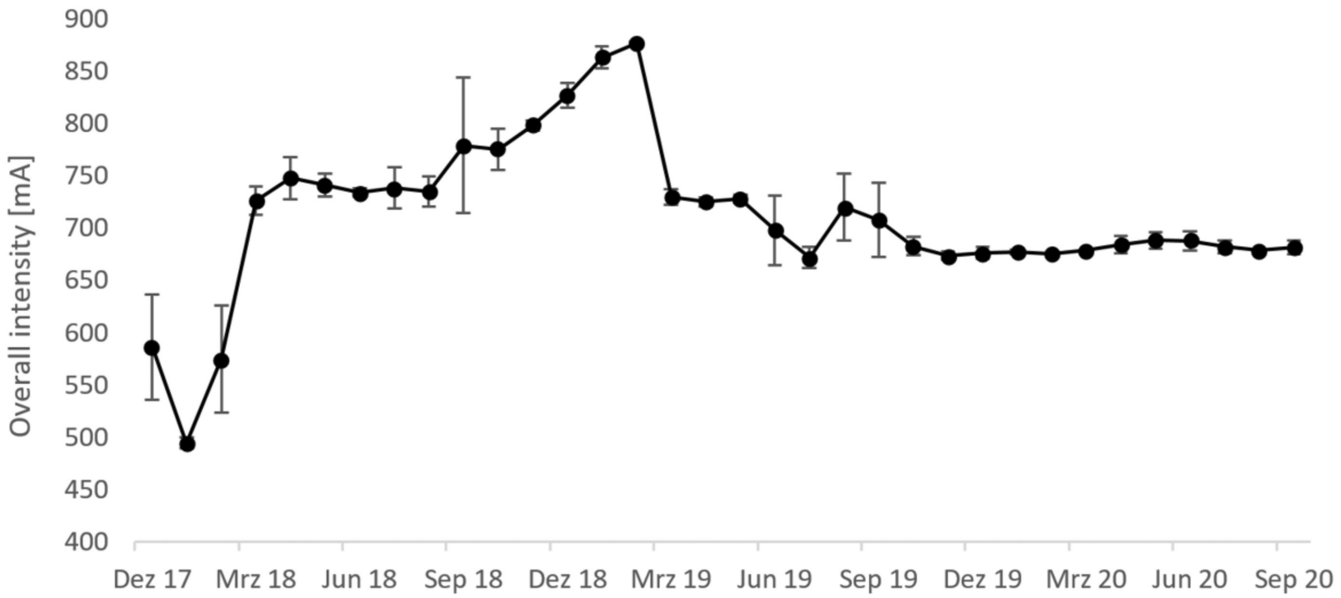

FIGURE 3 WB-EMS overall intensity as the sum of the individual stimulation intensity values per body region (legs, buttocks, lower back, upper back, rips, abdomen, chest, arms, and calves).

TABLE 2 Absolute values of physical function throughout the study period.

	T1 Oct/2017	T2 Feb/2018	T3 May/2018	T4 Oct/2018	T5 Mar/2019	T6 Sep/2020
Lung function						
Forced vital capacity (L)	3.2	n.a.	3.3	3.0	2.9	2.5
Forced expiratory volume in 1 s (L)	2.8	n.a.	2.5	2.6	2.5	2.2
Tiffeneau-Pinelli index (%)	86.5	n.a.	75.0	86.1	84.9	89.9
Blood parameters						
Leukocytes ($\times 10^3 \cdot \mu L^{-1}$)	9.3	n.a.	n.a.	8.2	7.1	6.6
Erythrocytes ($\times 10^6 \cdot \mu L^{-1}$)	4.9	n.a.	n.a.	4.6	4.6	4.3
Hemoglobin ($g \cdot dl^{-1}$)	15.4	n.a.	n.a.	15.0	14.3	13.8
Hematocrit (%)	46.2	n.a.	n.a.	42.7	42.4	41.0
Platelets ($\times 10^3 \cdot \mu L^{-1}$)	198.0	n.a.	n.a.	163.0	175.0	189.0
Lymphocytes ($\times 10^3 \cdot \mu L^{-1}$)	3.5	n.a.	n.a.	4.1	3.4	2.8
Neutrophils ($\times 10 \cdot \mu L^{-1}$)	4.9	n.a.	n.a.	3.3	3.2	3.1
Creatine kinase ($U \cdot l^{-1}$)	1072	n.a.	n.a.	880	887	972
C-reactive protein ($mg \cdot l^{-1}$)	1.0	n.a.	n.a.	0.1	1.0	0.0
Erythrocyte sedimentation rate ($mm \cdot h^{-1}$)	13/24	n.a.	n.a.	8/18	7/18	16/26
Neutrophil to lymphocyte ratio	1.4	n.a.	n.a.	0.8	0.9	1.1
Platelet to lymphocyte ratio	56.6	n.a.	n.a.	39.8	51.5	67.5
Systemic inflammation index	277.2	n.a.	n.a.	131.2	164.7	209.9

Abbreviation: n.a, not assessed.

T6, respectively with some exceptions (Tables 2, 4). The CK values were elevated at baseline but within a disease-related range. CK values remained elevated but slightly decreased over time by −17.9 (T4), −17.3 (T5) and −9.3% (T6).

3.3 | Functional assessments and physical performance

VO_{2peak} increased by 7% from T1 to T3 but decreased afterwards by −11.2 (T4), −6.4 (T5) and −55.6% (T6). Peak power output decreased over time in comparison to T1 (T3: −2.9; T4: −3.6; T5: −11.6 and T6: −48.3%). The patient stated that it was difficult to complete and tolerate the required pedaling resistance on the bicycle ergometer due to reduced leg strength. Furthermore, we had to implement another increment of pedaling without resistance in T6 (Figure 4).

The CRTm and TUGm improved in T2, T3, T4 and T5 before decreasing in T6 while the 6MWT improved in T2 and T3 before decreasing in T4, T5 and T6 (Tables 3, 4).

Patient reported outcomes showed similar developments like the physiological parameters. Both, the IBM-FRS and the SF-36 values decreased over time with the worst result having been observed at T6 (Figure 5).

4 | DISCUSSION

This case report aimed to evaluate the effects of WB-EMS on physical functioning and QoL in a 70-year-old male with severe IBM. This was the first trial to use WB-EMS for muscle weakness, physical functioning, and QoL in IBM. Regular combined training with WB-EMS and dynamic movements initially led to slight improvements in physical functioning and reduced systemic inflammation, suggesting

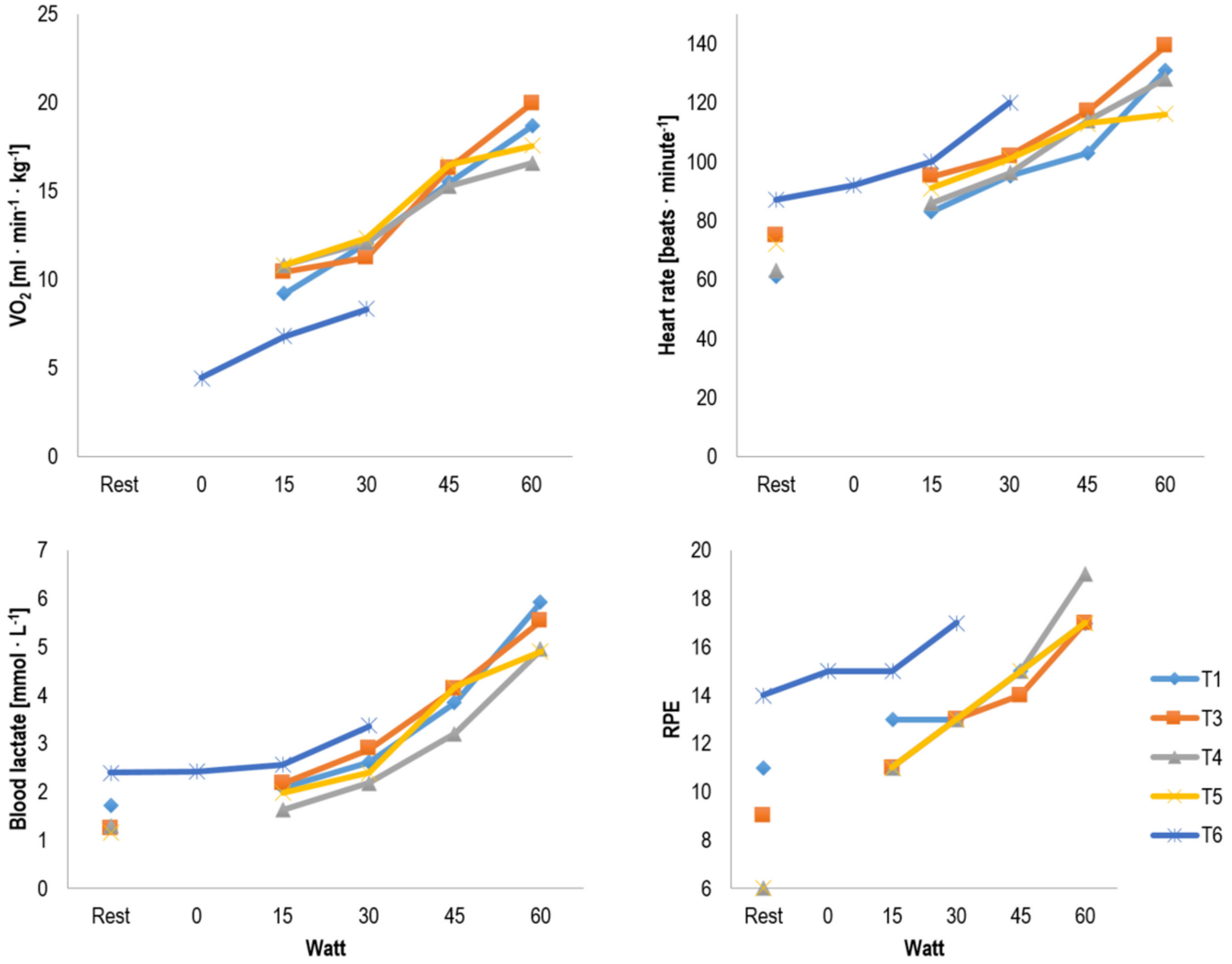

FIGURE 4 Oxygen uptake, heart rate as well as blood lactate and rated perceived exertion parameter during the cardiopulmonary exercise testing; 0 watt increment only implemented in T6; VO_2 was not assessed in resting, as the mask was applied due to discomfort immediately prior to the commencement of the test.

TABLE 3 Functional assessments and physical performance throughout the study period.

	T1 Oct/2017	T2 Feb/2018	T3 May/2018	T4 Oct/2018	T5 Mar/2019	T6 Sep/2020
Functional tests						
Modified Chair Rise Test (s)	22.6	11.9	12.4	12.0	12.7	41.6
Modified Timed Up and Go Test (s)	14.6	13.3	13.6	14.1	13.9	16.2
6-Min Walking Test (m)	353	357	360	333	332	227
Cardiopulmonary exercise testing						
Peak oxygen uptake ($ml \cdot min^{-1} \cdot kg^{-1}$)	18.7	n.a.	20.0	16.6	17.5	8.3[a]
Peak power output (W)	58.0	n.a.	56.3	55.9	51.3	30.0

Abbreviation: n.a., not assessed.

[a]Terminated due to inability to keep the required frequency of pedaling following muscle weakness.

TABLE 4 Blood parameters, lung function and functional assessment changes over all time points in comparison to T1.

Parameters	Feb/2018 Δ% T1–T2	May/2018 Δ% T1–T3	Oct/2018 Δ% T1–T4	Mar/2019 Δ% T1–T5	Sep/2020 Δ% T1–T6
Blood parameters					
Leukocytes	n.a.	n.a.	−11.8	−23.7	−29.0
Erythrocytes	n.a.	n.a.	−6.1	−6.1	−12.2
Hemoglobin	n.a.	n.a.	−2.6	−7.1	−10.4
Hematocrit	n.a.	n.a.	−3.5	−3.8	−5.2
Platelets	n.a.	n.a.	−17.7	−11.6	−4.5
Lymphocytes	n.a.	n.a.	+17.1	−2.9	−20.0
Basophils, eosinophils, monocytes	n.a.	n.a.	−11.1	−44.4	−66.7
Neutrophils	n.a.	n.a.	−32.7	−34.7	−36.7
Creatine kinase	n.a.	n.a.	−17.9	−17.3	−9.3
C-reactive protein	n.a.	n.a.	−90.0	±0.0	−100
Neutrophil to lymphocyte ratio	n.a.	n.a.	−42.9	−35.7	−21.4
Platelet to lymphocyte ratio	n.a.	n.a.	−29.7	−9.0	+19.3
Systemic inflammation index	n.a.	n.a.	−52.7	−40.6	−24.3
Lung function					
Forced vital capacity	n.a.	+3.1	−6.3	−9.4	−21.9
Forced expiratory volume in 1 s	n.a.	−10.7	−7.1	−10.7	−21.4
Functional assessments					
Modified Chair Rise Test	−47.3	−45.1	−46.9	−43.8	+84.1
Modified Timed Up and Go Test	−8.9	−6.8	−3.4	−4.8	+11.0
6-Min Walking Test	+1.1	+2.0	−5.7	−5.9	−35.7

Abbreviation: n.a., not assessed.

a slower progression rate. VO_{2peak} increased from baseline to T3, while peak power output decreased at all time points, indicating ongoing muscle loss. Functional assessments showed initial improvement from baseline to T2, remaining relatively constant until T5, before strongly decreasing at T6. However, QoL values declined from the start, reaching their lowest at T6. The 6MWT initially increased before decreasing from T4, mirroring the VO_{2peak} response and indicating a strong relationship between these measures.[29]

BIA indicates the typical distinct muscle atrophy. Body fat-free mass between 42.1–45.7 kg was below the age-related reference (58.5 ± 5.4 kg; 59.7 ± 5.3 kg) and disease-related (50.5–51.9 kg) reported values.[15,30,31] Not surprisingly, reduced muscle mass leads to a deterioration in physical functioning, which in turn leads to more difficulties in coping with everyday life also explaining the reduction of the IBM-FRS and the SF-36 values over time with the worst results in September 2020.

FIGURE 5 Inclusion body myositis functional rating scale (IBM-FRS) and short-form (36) health survey (SF-36) scores throughout the intervention period.

Similar to skeletal muscle atrophy, also the respiratory muscles are affected by the disease often leading to respiratory failure.[4] Combined with the muscle weakness, these might explain the deterioration in CPET but also in lung function. Despite minor changes in low-grade inflammation (neutrophil to lymphocyte ratio, platelet to lymphocyte ratio, systemic inflammation index and C-reactive protein), the measured values were within the range of age-related reference values[17,32] and the prognostic value of these parameters in IBM needs to be further investigated.

As the CK values were above age-related normal values but within the disease expected reported values[9] and did not exceed the baseline values, WB-EMS seems to have been well tolerated. Our intervention showed an initial improvement in some performance parameters, followed by a plateau and/or even a decline in performance towards the end of the intervention period. These inconclusive adaptations could indicate a slow progression that appears to be undulating rather than straightforward, affecting individual performance parameters differently also explaining the different performance responses found in our study. In addition, the patient underwent ADT starting in 2019, which may have further contributed to a decline in physical function.[33,34] Furthermore, the patient was diagnosed with diabetes, which can lead to a vicious cycle of muscle mass loss and, consequently, disease progression.[35] This cycle can exacerbate both diabetes and cardiovascular issues[35] and may also contribute to the progression of IBM.

Unfortunately, we were not able to compare the effects of our intervention on the progression rate to a control situation. Thus, it is of importance to identify

the physiological mechanisms causing the progression to be able to target them. Furthermore, there is an urgent need for standardized criteria for exercise tests in this area, which is also indicated by the modifications of standardized functional assessments like the TuG.

This was the first study to implement WB-EMS in IBM, though further research has evaluated passive neuromuscular and muscular electrical stimulation (NMES) which includes WB-EMS on chronic conditions such as respiratory, heart, metabolic and oncological diseases.[36,37] A previous Cochrane review concludes that NMES may effectively treat muscle weakness and improve some functional assessments in adults with advanced progressive disease and could be used in rehabilitation programs.[36] These results are partially corroborated by another systematic review, but the authors identified significant bias in some of the studies, thereby rendering the results controversial.[37]

Further studies of exercise therapy in IBM need to identify reliable physical functioning and physiological (performance) markers as well as to introduce exercise guidelines, also considering the progressive nature of IBM. Another aspect of a multidisciplinary and comprehensive approach would be the combination of structured exercise with ergogenic aids such as supplementation with essential amino or fatty acids, proteins, creatine, hormones, vitamins, or enzymes. Currently, there is no evidence that any particular diet or supplementation leads to improvements in the treatment of IBM.[38] Additionally, the exploration of further passive muscle stimulation methods, such as blood flow restriction (BFR) training or vibration training, should be considered. A promising case report using BFR training in IBM showed improvements in functional assessments.[17] However, a subsequent randomized controlled trial based on these findings did not identify clear improvements but rather more preservative results.[39]

5 | CONCLUSION

Our data suggest that supportive exercise programs focusing on external muscle stimulation, possibly combined with active muscle contraction, could improve physical functioning and performance in IBM. WB-EMS training appears to be well tolerated and safe. Initially, WB-EMS led to significant improvements in functional assessments related to everyday activities, though these declined over time due to disease progression and multimorbidity. Other physiological and clinical parameters showed variable responses, reflecting the complexity of the condition.

AUTHOR CONTRIBUTIONS

Nils Freitag: Conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing – original draft; writing – review and editing. **Boris Dragutinovic:** Data curation; investigation; visualization; writing – original draft; writing – review and editing. **Hannah L. Notbohm:** Data curation; investigation; visualization; writing – original draft; writing – review and editing. **Andre Filipovic:** Data curation; investigation; writing – original draft; writing – review and editing. **Thorsten Schiffer:** Data curation; investigation; writing – original draft; writing – review and editing. **Wilhelm Bloch:** Conceptualization; data curation; investigation; methodology; writing – original draft; writing – review and editing. **Moritz Schumann:** Conceptualization; data curation; methodology; supervision; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

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