Impaired physical function in patients with idiopathic inflammatory myopathies: results from the multicentre COVAD patient-reported e-survey

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Running Title:

Impaired physical function in IIMs: results from the COVAD e-survey

Abstract

Objectives: The assessment of physical function is fundamental in the management of patients with idiopathic inflammatory myopathies (IIMs). We aimed to investigate the physical function of patients with IIMs compared to those with non-IIM autoimmune rheumatic diseases (AIRDs) utilizing Patient-Reported Outcome Measurement Information System (PROMIS) Physical Function (PF) data obtained in the COVAD study, an international self-reported e-survey assessing the safety of COVID-19 vaccines in AIRDs.

Methods: Demographics, AIRD diagnosis, disease activity, and PROMIS PF short form-10a data were extracted from the COVAD database. PROMIS PF-10a scores were compared between disease categories and stratified by disease activity. Factors affecting PROMIS PF-10a scores other than disease activity were identified by multivariable regression analysis in patients with inactive disease.

Results: 1057 IIM patients, 3635 non-IIM AIRD patients, and 3981 healthy controls (HCs) responded to the COVAD e-survey from April to August 2021. Using a binomial regression model, the predicted mean of PROMIS PF-10a scores was significantly lower in IIM patients compared to non-IIM AIRD patients or HCs (36.3 [95% confidence interval (CI) 35.5–37.1] vs. 41.3 [95%CI 40.2–42.5] vs. 46.2 [95%CI 45.8–46.6], $P < 0.001$), irrespective of disease activity. The independent factors for lower PROMIS PF-10a scores in patients with inactive disease were older age, female, longer disease duration, and a diagnosis of inclusion body myositis or polymyositis.

Conclusion: Physical function is significantly impaired in IIMs compared to non-IIM AIRDs or HCs, even in patients with inactive disease. Our study highlights a critical need for better strategies to minimize functional disability in patients with IIMs.

Keywords

Myositis, physical function, patient-reported outcome measures, PROMIS, COVAD, e-survey

Key messages

- Physical function is significantly impaired in IIMs compared to other AIRDs, regardless of disease activity.
- PROMIS PF-10a scores were the lowest in IBM among IIMs.
- Older age, female, and disease duration were the independent factors for lower PROMIS PF-10a scores.

Introduction

Idiopathic inflammatory myopathies (IIMs) are a group of systemic autoimmune rheumatic diseases (AIRDs) that can affect multiple organs, including skeletal muscle, skin, lungs, heart, and joints [1]. IIMs are now recognized as a heterogeneous disease spectrum that encompasses dermatomyositis (DM), amyopathic dermatomyositis (ADM), polymyositis (PM), overlap myositis, immune-mediated necrotizing myopathies (IMNM), anti-synthetase syndrome (ASSD), and inclusion body myositis (IBM) [2]. One of the most prevalent clinical features in IIMs is muscle weakness, which, along with other organ-specific manifestations, may negatively affect physical function and health-related quality of life (HRQoL) [3, 4]. Therefore, the assessment of physical function is critical in the management of IIMs.

Physical function can be evaluated in several ways, including objective measurements such as task-oriented tests, and patient-reported outcome measures (PROMs). The importance of PROMs has been increasingly recognized in complex, chronic diseases with subjective and heterogenous symptoms, especially in the era of coronavirus disease-2019 (COVID-19) pandemic [5-7]. In patients with IIMs, the Health Assessment Questionnaire - Disability Index (HAQ-DI) has been included as a functional PROM in the International Myositis and Clinical Studies Group (IMACS) disease activity core set measures [8]. In 2004, the Patient-Reported Outcomes Measurement Information System (PROMIS®) was established as a National Institute of Health initiative to develop PROMs with improved validity and efficacy [9]. PROMIS is based on the item response theory and includes measures to assess a patient's physical, social, and emotional functioning. PROMIS physical function items can be administered through computerized adaptive tests or fixed-length short forms, which have previously been validated in rheumatoid arthritis patients [10-12]. Recently, Saygin et al. investigated the psychometric properties of PROMIS Short Form v1.0 - Physical Function 20a (PROMIS PF-20) in a cohort of fifty adult IIMs for the first time. PROMIS PF-20 demonstrated favourable reliability, validity, and responsiveness for clinical change in IIM patients [13]. However, to date, no attempts have been made to compare the physical function status of patients with IIMs and non-IIM AIRDs using the PROMIS PF Short Forms.

The COVID-19 pandemic has posed a significant impact on the management of patients with AIRDs. In an anonymous international e-survey conducted in April–May 2020 focusing on the situation surrounding IIM patients during the pandemic, nearly one in four (26.3%) of IIM patients had difficulty in procuring medical care. Scheduled biologic infusions and physiotherapies were interrupted in 21.7% and 35.2% of the patients, respectively [7]. The disruption of clinical care could have led to worse physical function in patients with IIMs compared to the pre-pandemic era. The COVID-19 Vaccination in Autoimmune Diseases (COVAD) study is a large-scale, international self-reported e-survey to assess the safety of COVID-19 vaccines in patients with IIMs compared to those with non-IIM AIRDs and healthy controls (HCs) [14]. Questions corresponding to PROMIS Short Form v2.0 - Physical Function 10a (PROMIS PF-10a) were incorporated into the survey form, given its simplicity and feasibility. In this context, the present study aimed to investigate the physical function status of IIM patients in comparison with non-IIM AIRD patients and HCs, utilizing PROMIS PF-10a data obtained in the COVAD survey.

Methods:

The COVAD study

The survey design of the COVAD study is reported in detail elsewhere [14]. Briefly, participants were eligible if they were > 18 years old, regardless of being diagnosed with AIRDs or not. The questionnaire comprised 36 COVID-19 and AIRD-related questions regarding 1) demographics, 2) previous COVID-19 infection, 3) vaccination status, 4) short-term adverse effects of the vaccine, 5) the diagnosis, treatment history, and current status of AIRDs, and 6) functional status. The survey form was pilot tested, validated, and translated into 18 languages on surveymonkey.com. The study was launched in April 2021 and continued until December 31, 2021. As of August 2021, 16,327 responses had accrued,

which were analysed in the present study. Written informed consent was obtained from every participant at the beginning of the survey form. The COVAD study was approved by the Institutional Ethics Committee of Sanjay Gandhi Postgraduate Institute of Medical Sciences (2021-143-IP-EXP-39) and conducted according to the Declaration of Helsinki.

Data extraction

The survey data regarding demographics, AIRD diagnosis, disease activity, general health status, ability to carry out routine activities, fatigue, pain, and PROMIS PF-10a were extracted from the COVAD study database. The questions asked in the COVAD survey that correspond to each domain are presented in Supplementary Table S1, available at *Rheumatology* online.

The disease activity of each patient was assessed in three different ways: (1) physician's assessment (active defined as an increase in the dose of or initiation of any immunosuppressive drugs in the six months prior to the first COVID-19 vaccination), (2) patient's assessment (active defined as the patient's perception of his/her disease as active in the four weeks prior to the first dose of COVID-19 vaccination), and based on (3) current corticosteroid use (active defined as a patient taking any doses of corticosteroids within four weeks prior to the first COVID-19 vaccination). The three definitions were applied independently to each patient, and the consistency was analysed statistically. Fatigue and pain were assessed with a 10-cm visual analogue scale (VAS). Both general health status and the ability to carry out routine activities were rated on 5-point Likert scales (excellent/very good/good/fair/poor, and completely/mostly/moderately/a little/not at all, respectively).

PROMIS PF-10a scores

PROMIS PF-10a is a 10-item questionnaire, with each item scored on a 5-point scale. The first five questions assess the degree to which the patient's current physical function limits her/his life, with the answer choices ranging from 1 = "cannot do" to 5 = "without any difficulty". The remaining five questions evaluate the ability to carry out specific functional activities, and the answer choices range from 1 = "unable to do" to 5 = "without any difficulty". The final score (range 10–50) is calculated by a sum of individual scoring, with higher scores indicating better physical function. The list of questions included in the COVAD survey corresponding to PROMIS PF-10a is presented in Supplementary Table S2, available at *Rheumatology* online.

Statistical analysis

Continuous variables are presented as the median with interquartile range (IQR). For descriptive statistics, the Kruskal-Wallis test and chi-square test were used for continuous and categorical variables, respectively. The consistency of the three different definitions of disease activity was assessed with McNemar's test.

PROMIS PF-10a scores were compared between each disease category, stratified by 1) disease activity based on the three definitions stated above, 2) general health status, and 3) the ability to carry out routine activities. To make a comparison between each subgroup, multivariable regression analysis adjusted for age, gender, and ethnicity was performed clustering countries using the negative binomial regression model, because the PROMIS PF-10a score was an over-dispersed count data. The predicted PROMIS PF-10a score was calculated based on the regression result. The association between fatigue or pain VAS and PROMIS PF-10a scores was also assessed with the multivariable analysis. In order to elucidate the factors other than disease activity affecting PROMIS PF-10a scores, another multivariable regression analysis was conducted with disease category, age, gender, ethnicity, and disease duration as covariates in patients with inactive diseases (IIMs and non-IIM AIRDs). A two-sided P-value < 0.05 was considered

statistically significant. All statistical analyses were performed using STATA version 16 (StataCorp. 2019. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC).

Results

Patients and HCs

The demographic information of the study participants is summarized in Table 1. A total of 8673 complete responses from 1057 IIM patients, 3635 non-IIM AIRD patients, and 3981 HCs (those without AIRDs) were analysed. The median age of the respondents was 43 [IQR 30–56] years, and 74.8% were female. As for ethnicity, Caucasians were the most prevalent (57.1%), and Asians were the second (23.2%). Compared to non-IIM AIRD patients or HCs, IIM patients were older (IIMs: 60 [49–70] years old vs. non-IIM AIRDs: 47 [37–58] years old vs. HCs: 33 [25–47] years old, median [IQR], $P < 0.001$), and more likely to be Caucasian (IIMs: 83.2%, non-IIM AIRDs: 63.1%, HCs: 44.7%, $P < 0.001$). Disease duration was shorter in IIMs compared to non-IIM AIRDs (IIMs: 6 [3–13] years vs. non-IIM AIRDs: 8 [3–15] years, median [IQR], $P < 0.001$]). Among IIM patients, DM was the most prevalent diagnosis (34.8%), followed by IBM (23.6%), PM (16.2%), ASSD (11.8%), overlap myositis (7.9%), and IMNM (4.6%). In terms of non-IIM AIRDs, rheumatoid arthritis (RA) was the most common (23.9%), followed by autoimmune thyroid disease (15.1%), and systemic lupus erythematosus (10.2%).

Disease activity

The disease activity of each patient was assessed based on the three different definitions stated above (Figure 1 and Supplementary Table S3, available at *Rheumatology* online). A total of 3441 IIM and non-IIM AIRD patients were judged as having active disease by at least one definition, while 911 patients were considered to have inactive disease with all the three definitions. Of note, the proportions of patients assessed as having active disease varied substantially according to which of the three definitions was applied, with more cases judged as active by patient's assessment compared to physician's assessment or corticosteroid use ($P < 0.001$). For example, among IIMs, 189 (17.9%), 809 (83.5%), and 438 (41.6%) patients were considered to have active disease according to physician's assessment, patient's assessment, and corticosteroid use, respectively. A similar tendency was also observed in non-IIM AIRD patients, in whom 581 (16.0%), 2269 (69.6%), and 838 (23.1%) were judged as having active disease. Therefore, the three definitions were applied separately in the subsequent analysis.

PROMIS PF-10a scores in each disease category

PROMIS PF-10a scores in each disease category are presented in Figure 2. The predicted mean of PROMIS PF-10a scores was lower in IIM patients compared to non-IIM AIRD patients or HCs (36.3 [95% CI 35.5–37.1] vs. 41.3 [95% CI 40.2–42.5] vs. 46.2 [95% CI 45.8–46.6], $P < 0.001$) when adjusted for age, gender, and ethnicity (Figure 2A). Considering the subgroups of IIMs, the scores were significantly lower in IBM in comparison with non-IBM IIMs ($P < 0.001$) (Figure 2B). Since the lower predicted mean of PROMIS PF-10a scores in IIMs could be the result of tremendously low scores in patients with IBM, we performed a sensitivity analysis excluding IBM. The predicted mean of PROMIS PF-10a scores were still significantly lower in PM (37.1 [95%CI 36.1–38.1]), ASSD (38.1 [95%CI 37.3–38.8]), overlap myositis (37.1 [95%CI 34.5– 39.7]), and IMNM (34.5 [95%CI 32.7–36.3]) compared to non-IIM AIRDs (40.5 [95%CI 39.3–41.6]) (Supplementary Table S4, available at *Rheumatology* online).

PROMIS PF-10a scores and disease activity

The association of PROMIS PF-10a scores and disease activity defined by the three different definitions is shown in

Figure 3. As expected, PROMIS PF-10a scores were significantly lower in patients with active disease than in those with inactive disease in both IIMs and non-IIM AIRDs, irrespective of the definitions of disease activity used (physician's assessment, patient's assessment, or corticosteroid use). Importantly, the scores were again lower in patients with IIMs than in those with non-IIM AIRDs ($P < 0.001$), regardless of disease activity (active or inactive), or the definitions of disease activity used.

General health status or ability to carry out routine activities and PROMIS PF-10a scores

PROMIS PF-10a scores were stratified by the participants-reported general health status or the ability to carry out routine activities (Figure 4). PROMIS PF-10a scores correlated well with general health status in every disease category ($P < 0.001$) (Figure 4A). The scores were also in correlation with the ability to carry out routine activities in IIMs, but not in non-IIM AIRDs or HCs (Figure 4B). Notably, PROMIS PF-10a scores were again lower in IIMs compared to non-IIM AIRDs or HCs in whom general health status was rated as fair, good, or very good, and regardless of the ability to carry out routine activities.

Fatigue or pain VAS and PROMIS PF-10a scores

The association of fatigue or pain VAS and PROMIS PF-10a scores was assessed with multivariable analysis adjusted for age, gender, and ethnicity (Supplementary Table S5, available at *Rheumatology* online). As expected, higher pain or fatigue VAS was associated with lower PROMIS PF-10a scores in each disease category ($P < 0.001$), while the predicted mean of PROMIS PF-10a scores was still lower in IIMs compared to non-IIM AIRDs even after being adjusted for fatigue and pain (37.2 [95% CI 36.0–38.4] vs. 42.6 [95% CI 42.0–43.2], $P < 0.001$).

Factors affecting PROMIS PF-10a scores in patients with inactive disease

To identify the factors affecting PROMIS PF-10a scores other than disease activity, multivariable regression analysis was performed in patients with inactive disease based on the three different definitions of disease activity (Table 2). Older age, female gender, longer disease duration, and a diagnosis of IBM or PM were identified as independent factors for lower PROMIS PF-10a scores, regardless of the definitions of disease activity used. Interestingly, when the disease activity was defined by the patient's assessment, Hispanic ethnicity was found to be another independent risk factor for lower PROMIS PF-10a scores. The adjusted PROMIS PF-10a scores were again the lowest in IBM among IIMs, irrespective of the applied disease activity definition.

Discussion

The evaluation of physical function is fundamental in the management of IIM patients. PROMIS physical function measure demonstrated favourable psychometric properties in adult IIMs [13]. Given its simplicity and feasibility, PROMIS PF-10a Short Form was incorporated into the COVAD study, a large-scale, international e-survey assessing the safety of COVID-19 vaccines in IIMs compared to non-IIM AIRDs and HCs. Our study highlights that PROMIS PF-10a scores in IIM patients are significantly lower compared to non-IIM AIRD patients or HCs, regardless of disease activity. Among IIMs, PROMIS PF-10a scores were the lowest in IBM. PROMIS PF-10a scores correlated well with participants-reported general health status or the ability to carry out routine activities. Moreover, higher pain or fatigue VAS was associated with lower PROMIS PF-10a scores, while the scores were lower in IIMs compared to non-IIM AIRDs even after being adjusted for fatigue and pain. Multivariable analysis revealed that independent factors affecting PROMIS PF-10a scores other than disease activity were older age, female gender, longer disease duration, and a diagnosis of IBM or PM. These results imply that physical function is significantly impaired in IIM patients, especially in IBM, in comparison with non-IIM AIRD patients or HCs.

The COVID-19 pandemic has incurred a considerable impact on the clinical care of AIRD patients. The interruption of scheduled infusion therapies and physiotherapy sessions [7] could have resulted in worse physical function status of IIM patients compared to the pre-pandemic era. Therefore, the COVAD database could be biased towards lower PROMIS PF-10a scores. Further studies are necessary to clarify the effect of the COVID-19 pandemic on the physical function and HRQoL of IIM patients. Meanwhile, it should be noted that the COVAD survey has an inherent recruitment bias due to convenient sampling, where patients with low PROMIS PF-10a scores might have been missed.

The lower PROMIS PF-10a scores in IIMs compared to non-IIM AIRDs even in those with inactive disease suggest considerable damage accumulation in IIM patients. In fact, longer disease duration was one of the independent factors for lower PROMIS PF-10a scores in patients with inactive disease. Despite combined treatments with corticosteroids and immunosuppressive drugs, it is difficult to achieve complete remission in IIMs [15,16], and a majority of patients remain on corticosteroid treatment for years [16]. Long-term corticosteroid therapy is associated with significant morbidity in IIM patients, including steroid-induced myopathy, osteoporosis with fracture, and avascular necrosis [17]. Cumulative damage arising from both the underlying disease and corticosteroid treatment might explain the low PROMIS PF-10a scores of IIM patients illustrated in the present study. Previous studies reported that the HRQoL of IIM patients was significantly reduced compared to those with non-IIM AIRDs especially in the physical component [18, 19], in line with our findings. Taken together, our results highlight the need for better treatment strategies for patients with IIMs, in which the accrual of organ damage and deterioration of physical function or HRQoL are minimized, as well as appropriate non-pharmacologic approaches including physical therapy.

Of note, PROMIS PF-10a scores were the lowest in IBM among IIMs, even after the scores were adjusted for patients' age and gender. This result is consistent with a previous report, which revealed that HRQoL assessed by the Short Form-12 version 2 (SF-12v2®) was significantly reduced in IBM patients compared to non-IBM IIM patients [18]. Emerging therapies including synthetic immunomodulators and biological agents have improved outcomes of IIM patients [20, 21], however, the treatment options are still limited in IBM. Immunosuppressive treatments including corticosteroid, methotrexate, and intravenous immunoglobulin have shown limited to no efficacy in blinded placebo-controlled trials [22]. The treatment refractory nature of IBM disease leads to damage accumulation, which could have led to the significantly lower PROMIS scores of IBM patients compared to those with other IIMs in the present study. In IBM and IMNM, the PROMIS PF-10a scores were comparable between active

and inactive cases, suggesting significant damage accumulation in patients with inactive disease. Also, in the multivariable analysis targeting those with inactive disease, a diagnosis of IBM or PM was an independent factor for lower PROMIS scores. These findings might be highlighting the refractoriness to conventional therapies and cumulative damage in patients with PM or IMNM as well as IBM.

Interestingly, the proportions of active disease differed significantly depending on which type of disease activity definition was applied, with more patients judged as having active disease by patient's assessment than by physician's assessment or corticosteroid use. The discrepancy between patient's and evaluator's disease activity assessment in AIRDs is a frequently reported phenomenon, especially in RA [23, 24], often with worse assessment by patients. In RA patients, higher pain scores, tender joint count, and depressive symptoms were found to be the determinants of the discrepancy [23–26]. In a recent cross-sectional study including 75 patients with adult IIMs, discordance in patient-physician's assessment of disease activity was observed in 21 cases (28%) [27]. Of these, patients scored higher than physicians in 18 cases (24%), with older age and personal history of depression as associated factors. In the present study, disease activity defined by the physician's assessment was substituted with treatment escalation within six months before the first COVID-19 vaccination, which could also have resulted in discordance. Our results warrant further studies including a large number of IIM patients to elucidate the prevalence and determinants of patient-physician discrepancy in disease activity assessment. When the disease activity was evaluated with the patient's assessment, Hispanic ethnicity was identified as an additional independent factor for lower PROMIS PF-10a scores in patients with inactive disease. This result is potentially highlighting the disparity in the socioeconomic situation surrounding AIRD patients in different regions or ethnicities, which could limit access to expert medical care.

The strength of our study is utilizing the COVAD survey data that included a large number of IIM and non-IIM AIRD patients globally, which enabled us to evaluate the physical function in IIM subtypes that have not been well characterized in terms of functional disability, such as IMNM and overlap myositis. Several limitations should be noted. First, given the self-reported nature of the e-survey, the diagnosis of AIRDs was not verified objectively. Specifically, some patients with IBM, and possibly those with IMNM and ASSD, could have been misclassified as PM. Disease activity was not assessed objectively either. To account for this, we tested the three different types of definitions for disease activity and analysed their consistency. Second, information regarding comorbidities, major organ involvement of AIRDs, and concomitant malignancies, which could negatively impact physical function, was not obtained in the present study. Also, PROMIS PF Short Forms exclude information on dysphagia, which is a major complication of those with IBM and scleroderma-myositis overlap that significantly affects patient's well-being and HRQoL. The effect of these covariates on PROMIS PF-10a scores and HRQoL will be investigated in an ongoing survey, COVAD-2 [28]. In the present study, PROMIS PF-10a was incorporated instead of PROMIS PF-20 given its simplicity and feasibility, however, PROMIS PF-10a has not been validated in IIMs. The relevance of PROMIS PF-10a should further be assessed in an academic cohort of patients with IIMs in comparison with other measures of disability. Another limitation arises from the accessibility of surveymonkey.com, which could have limited the inclusion of elderly patients unfamiliar with smart devices, and people in certain countries where there is a data protection law, resulting in selection bias of the participants. Our results should be validated in an international, multicentre cohort involving various AIRD patients of all ages and ethnicities.

In conclusion, our study highlights that physical function as assessed by the PROMIS PF-10a instrument is significantly impaired in patients with IIMs compared to those with non-IIM AIRDs or HCs, regardless of disease activity. It strongly supports the critical need for the development of therapeutic strategies to minimize organ damage and the adequate implementation of non-pharmacologic interventions including physical therapy to

maintain physical function in IIM patients. Further studies are necessary to elucidate the determinants and consequences of impaired physical function in IIMs.

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Author's contributions

Conceptualisation: AY, MK, NR, LG, VA, RA; Data curation: All authors; Formal analysis: AY, MK, MK, NR, LG; Funding acquisition: N/A; Investigation: AY, MK, MK, NR, VA, RA, LG, JBL; Methodology: AY, RA, LG, JBL, OD, HC; Software: LG; Validation: VA, RA, JBL, HC; Visualisation: RA, VA, LG; Writing-original draft: AY, MK, MK; Writing-review & editing: All authors.

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Disclosure statement

ALT has received honoraria for advisory boards and speaking for AbbVie, Gilead, Janssen, Lilly, Novartis, Pfizer, and UCB; EN has received speaker honoraria/participated in advisory boards for Celltrion, Pfizer, Sanofi, Gilead, Galapagos, AbbVie, and Lilly, and holds research grants from Pfizer and Lilly; HC has received grant support from Eli Lilly and UCB; consulting fees from Novartis, Eli Lilly, Orphazyme, Astra Zeneca; speaker for UCB, Biogen; IP has received research funding and/or honoraria from Amgen, AstraZeneca, Aurinia Pharmaceuticals, Eli Lilly and Company, Gilead Sciences, GlaxoSmithKline, Janssen Pharmaceuticals, Novartis, and F. Hoffmann-La Roche AG; JD has received research funding from CSL Limited; NZ has received speaker fees, advisory board fees, and research grants from Pfizer, Roche, AbbVie, Eli Lilly, NewBridge, Sanofi-Aventis, Boehringer Ingelheim, Janssen, and Pierre Fabre; OD has/had consultancy relationship with and/or has received research funding from or has served as a speaker for the following companies in the area of potential treatments for systemic sclerosis and its complications in the last three years: AbbVie, Acceleron, Alcimed, Amgen, AnaMar, Arxx, Baecon, Blade, Bayer, Boehringer Ingelheim, ChemomAb, Corbus, CSL Behring, Galapagos, Glenmark, GSK, Horizon (Curzion), Inventiva, iQvia, Kymera, Lupin, Medac, Medscape, Mitsubishi Tanabe, Novartis, Roche, Roivant, Sanofi, Serodapharm, Topadur, and UCB. Patent issued "mir-29 for the treatment of systemic sclerosis" (US8247389, EP2331143); RA has/had a consultancy relationship with and/or has received research funding from the following companies: Bristol Myers-Squibb, Pfizer, Genentech, Octapharma, CSL Behring, Mallinckrodt, AstraZeneca, Corbus, Kezar, AbbVie, Janssen, Alexion, Argenx, Q32, EMD-Serono, Boehringer Ingelheim, and Roivant; The rest of the authors have no conflict of interest relevant to this manuscript.

Ethics

Informed consent was obtained from every participant at the beginning of the survey form. The COVAD study was approved by the Institutional Ethics Committee of Sanjay Gandhi Postgraduate Institute of Medical Sciences (IEC code: 2021-143-IP-EXP-39) and conducted according to the Declaration of Helsinki.

Data availability statement

The data underlying this article is available from the corresponding author on reasonable request.

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Figure Legends

Figure 1. Disease activity assessment of patients with IIMs and non-IIM AIRDs by the three different definitions.
AIRD, autoimmune inflammatory rheumatic disease; IIM, idiopathic inflammatory myopathy.

Figure 2. PROMIS PF-10a scores in each disease category.
PROMIS PF-10a scores were compared (A) between IIMs, non-IIM AIRDs, and HCs, or (B) among the IIM subgroups. The scores were adjusted for age, gender, and ethnicity. Data are shown as the predicted mean with 95% confidence interval. ***P $<$ 0.001; AIRD, autoimmune inflammatory rheumatic disease; ASSD, anti-synthetase syndrome; DM, dermatomyositis; HC, healthy control; IIM, idiopathic inflammatory myopathy; IBM; inclusion body myositis; IMNM, immune-mediated necrotizing myopathies; JDM, juvenile dermatomyositis; OM, overlap myositis; PF, physical function; PM, polymyositis; PROMIS, Patient-Reported Outcome Information System.

Figure 3. PROMIS PF-10a scores stratified by disease activity.
Disease activity was either defined by (A) physician's assessment, (B) patient's assessment, or (C) current corticosteroid use. PROMIS PF-10a scores were adjusted for age, gender, and ethnicity. Data are shown as the predicted mean with 95% confidence interval. *P $<$ 0.05, **P $<$ 0.01, ***P $<$ 0.001; AIRD, autoimmune inflammatory rheumatic disease; ASSD, anti-synthetase syndrome; DM, dermatomyositis; HC, healthy control; IIM, idiopathic inflammatory myopathy; IBM; inclusion body myositis; IMNM, immune-mediated necrotizing myopathies; JDM, juvenile dermatomyositis; OM, overlap myositis; PF, physical function; PM, polymyositis; PROMIS, Patient-Reported Outcome Information System.

Figure 4. PROMIS PF-10a scores stratified by general health status or ability to carry out routine activities.
PROMIS PF-10a scores were stratified by (A) general health status, or (B) the ability to carry out routine activities. The scores were adjusted for age, gender, and ethnicity. Data are shown as the predicted mean with 95% confidence interval. *P $<$ 0.05, **P $<$ 0.01, ***P $<$ 0.001; AIRD, autoimmune inflammatory rheumatic disease; HC, healthy control; IIM, idiopathic inflammatory myopathy; NS, not significant; PF, physical function; PROMIS, Patient-Reported Outcome Information System.

Table 1. Demographics and PROMIS PF-10a scores of the study participants

Variables	IIMs n = 1057	non-IIM AIRDs n = 3635	HCs n = 3981	P^1
Age, median [IQR]	60 [49–70]	47 [37–58]	33 [25–47]	< 0.001
Female, n (%)	776 (73.4)	3119 (85.8)	2591 (65.1)	< 0.001
Race/Ethnicity, n (%)				
Caucasian	879 (83.2)	2295 (63.1)	1778 (44.7)	< 0.001
Asian	73 (6.9)	778 (21.4)	1163 (29.2)	< 0.001
Hispanic	49 (4.6)	395 (10.9)	745 (18.7)	< 0.001
Others	56 (5.3)	167 (4.6)	295 (7.4)	< 0.001
Disease duration (years), median [IQR]	6 [3–13]	8 [3–15]	NA	< 0.001
PROMIS PF-10a scores, median [IQR]	35 [27–43]	43 [36–48]	50 [47–50]	< 0.001

AIRD, autoimmune inflammatory rheumatic disease; HC, healthy control;
IIM, idiopathic inflammatory myopathy; IQR, interquartile range; NA, not applicable;
PF, physical function; PROMIS, Patient-Reported Outcome Information System.

1. Kruskal-Wallis test and chi-square test were used for continuous and categorical variables, respectively.

Table 1. (Continued)

Variables	DM n = 368	IBM n = 249	PM n = 172	ASSD n = 125	OM n = 84	IMNM n = 49	JDM n = 10
Age, median [IQR]	56 [46–66]	72 [66–77]	58 [47–68]	56 [47–65]	51 [41–58]	62 [55–71]	44 [31–53]
Female, n (%)	310 (84.2)	102 (41.0)	130 (75.6)	105 (84.0)	81 (96.4)	40 (81.6)	8 (80.0)
Race/Ethnicity, n (%)							
Caucasian	295 (80.2)	228 (91.6)	137 (79.7)	109 (87.2)	60 (71.4)	42 (85.7)	8 (80.0)
Asian	40 (10.9)	5 (2.0)	13 (7.6)	3 (2.4)	11 (13.1)	1 (2.0)	0
Hispanic	18 (4.9)	6 (2.4)	9 (5.2)	7 (5.6)	8 (9.5)	0	1 (10.0)
Others	15 (4.1)	10 (4.0)	13 (7.6)	6 (4.8)	5 (6.0)	6 (12.2)	1 (10.0)
Disease duration (years), median [IQR]	5 [2–12]	7 [3–11]	6 [3–13]	4 [2–7]	7 [3–16]	3 [1–8]	32 [19–38]
PROMIS PF-10a scores, median [IQR]	40 [32–45]	25 [18–32]	37 [30–43]	37 [31–43]	38 [29–45]	33 [25–44]	42 [37–45]

ASSD, anti-synthetase syndrome; DM, dermatomyositis; IBM; inclusion body myositis;
IMNM, immune-mediated necrotizing myopathies; IQR, interquartile range; JDM, juvenile dermatomyositis;
OM, overlap myositis; PF, physical function; PM, polymyositis;
PROMIS, Patient-Reported Outcome Information System; SD, standard deviation.

Table 2. Multivariable regression analysis for identifying factors affecting PROMIS PF-10a scores in patients with inactive disease

(A) Target sample: Patients with inactive disease based on physician's assessment

Covariates	Coefficient [95% CI]	$P > \|z\|$	Predicted mean of PROMIS PF-10a scores [95% CI]
Group			
Non-IIM AIRDs	Reference		40.8 [39.8 to 41.8]
DM	-0.03 [-0.07 to 0.01]	0.188	39.7 [37.9 to 41.5]
IBM	-0.40 [-0.43 to -0.37]	< 0.001	27.4 [26.7 to 28.1]
PM	-0.09 [-0.12 to -0.06]	< 0.001	37.4 [36.2 to 38.5]
ASSD	-0.05 [-0.09 to -0.01]	0.017	38.9 [37.8 to 39.9]
OM	-0.07 [-0.13 to -0.01]	0.025	38.2 [35.8 to 40.5]
IMNM	-0.21 [-0.28 to -0.13]	< 0.001	33.1 [30.9 to 35.3]
JDM	0.02 [-0.13 to 0.16]	0.798	41.6 [34.8 to 48.4]
Age	-0.004 [-0.01 to -0.003]	< 0.001	
Male	0.04 [0.03 to 0.06]	< 0.001	
Ethnicity (Reference: Caucasian)			
Asian	0.01 [-0.02 to 0.05]	0.529	
Hispanic	0.02 [-0.02 to 0.05]	0.386	
Others	-0.03 [-0.07 to 0.01]	0.203	
Disease duration	-0.001 [-0.003 to -0.0001]	0.034	

(B) Target sample: Patients with inactive disease based on patient's assessment

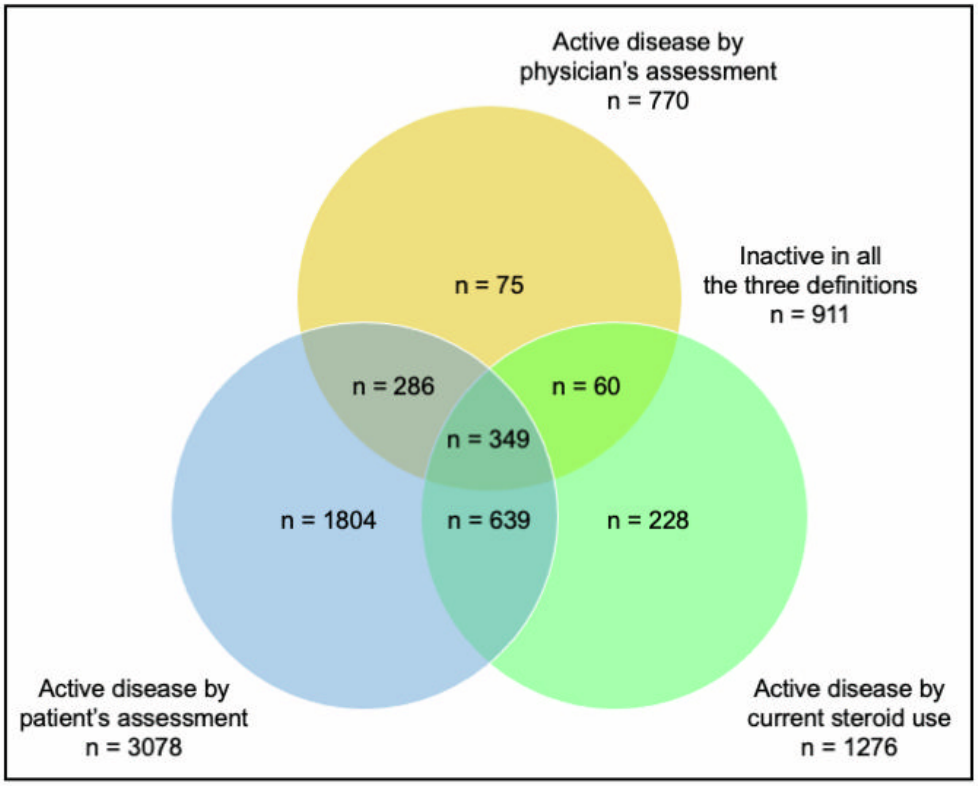
Covariates	Coefficient [95% CI]	$P > \|z\|$	Predicted mean of PROMIS PF-10a scores [95% CI]
Group			
Non-IIM AIRDs	Reference		44.3 [44.0 to 44.6]
DM	0.004 [-0.03 to 0.03]	0.805	44.5 [43.2 to 45.8]
IBM	-0.39 [-0.52 to -0.26]	< 0.001	30.0 [26.1 to 33.9]
PM	-0.07 [-0.12 to -0.03]	0.001	41.2 [39.5 to 42.9]
ASSD	-0.01 [-0.06 to 0.04]	0.760	44.0 [41.7 to 46.2]
OM	-0.09 [-0.23 to 0.06]	0.229	40.6 [34.7 to 46.4]
IMNM	-0.22 [-0.59 to 0.14]	0.233	35.4 [22.3 to 48.5]
JDM	0.01 [-0.17 to 0.19]	0.910	44.8 [36.7 to 52.9]
Age	-0.003 [-0.003 to -0.002]	< 0.001	
Male	0.03 [0.01 to 0.06]	0.016	
Ethnicity (Reference: Caucasian)			

Asian	-0.01 [-0.04 to 0.01]	0.347
Hispanic	-0.02 [-0.04 to -0.01]	< 0.001
Others	-0.04 [-0.07 to -0.01]	0.015
Disease duration	-0.002 [-0.003 to -0.00002]	0.047

(C) Target sample: Patients with inactive disease based on current steroid use

Covariates	Coefficient [95% CI]	$P > \|z\|$	Predicted mean of PROMIS PF-10a scores [95% CI]
Group			
Non-IIM AIRDs	Reference		41.2 [40.0 to 42.4]
DM	0.01 [-0.02 to 0.05]	0.496	41.7 [40.3 to 43.1]
IBM	-0.42 [-0.45 to -0.39]	< 0.001	27.1 [26.5 to 27.7]
PM	-0.07 [-0.11 to -0.03]	0.001	38.5 [37.3 to 39.7]
ASSD	-0.02 [-0.09 to 0.04]	0.464	40.2 [38.0 to 42.4]
OM	-0.08 [-0.16 to -0.01]	0.031	37.9 [34.7 to 41.1]
IMNM	-0.18 [-0.29 to -0.07]	0.002	34.4 [30.9 to 37.9]
JDM	0.11 [0.02 to 0.20]	0.014	46.0 [41.3 to 50.0]
Age	-0.004 [-0.004 to -0.003]	< 0.001	
Male	0.05 [0.03 to 0.07]	< 0.001	
Ethnicity (Reference: Caucasian)			
Asian	0.004 [-0.03 to 0.04]	0.843	
Hispanic	0.02 [-0.02 to 0.06]	0.372	
Others	-0.02 [-0.06 to 0.01]	0.131	
Disease duration	-0.001 [-0.003 to -0.0001]	0.030	

AIRD, autoimmune inflammatory rheumatic disease; ASSD, anti-synthetase syndrome; CI, confidence interval; DM, dermatomyositis; IIM, idiopathic inflammatory myopathy; IBM; inclusion body myositis; IMNM, immune-mediated necrotizing myopathies; JDM, juvenile dermatomyositis; OM, overlap myositis; PF, physical function; PM, polymyositis; PROMIS, Patient-Reported Outcome Information System.



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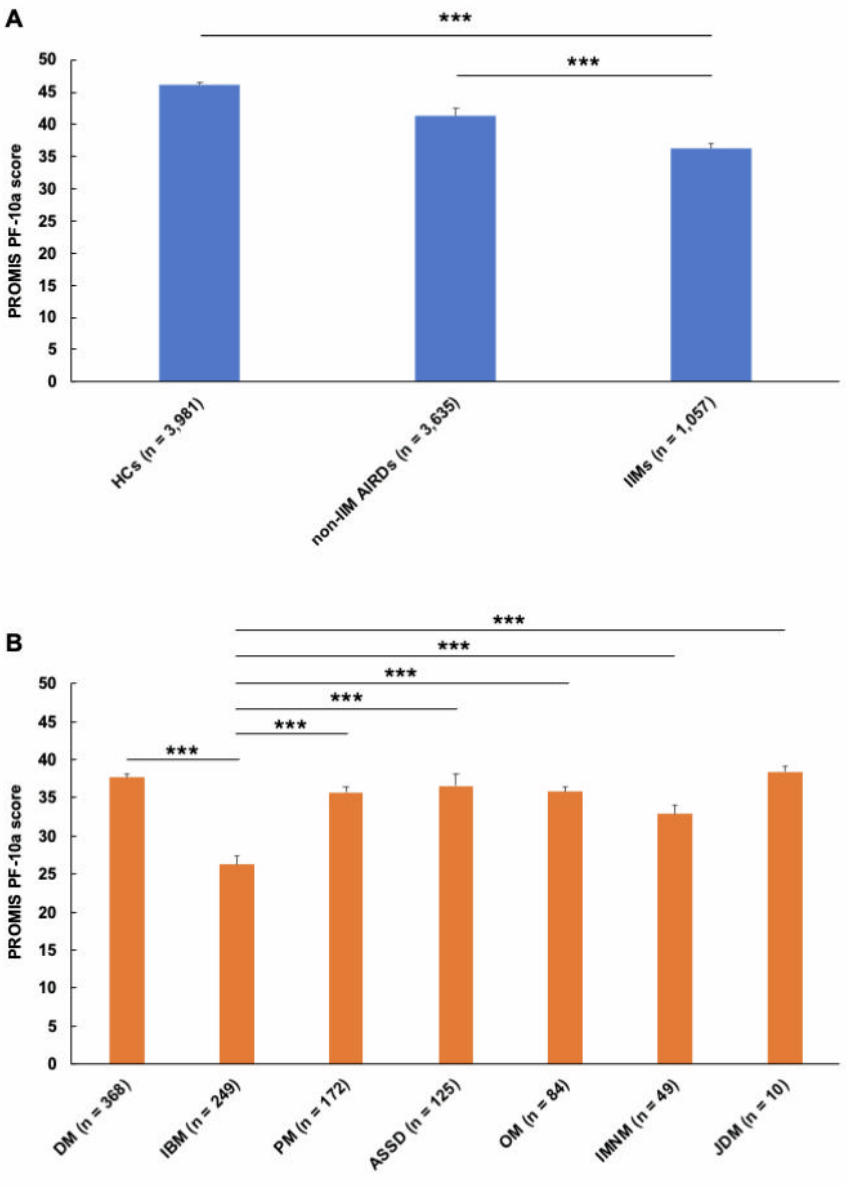

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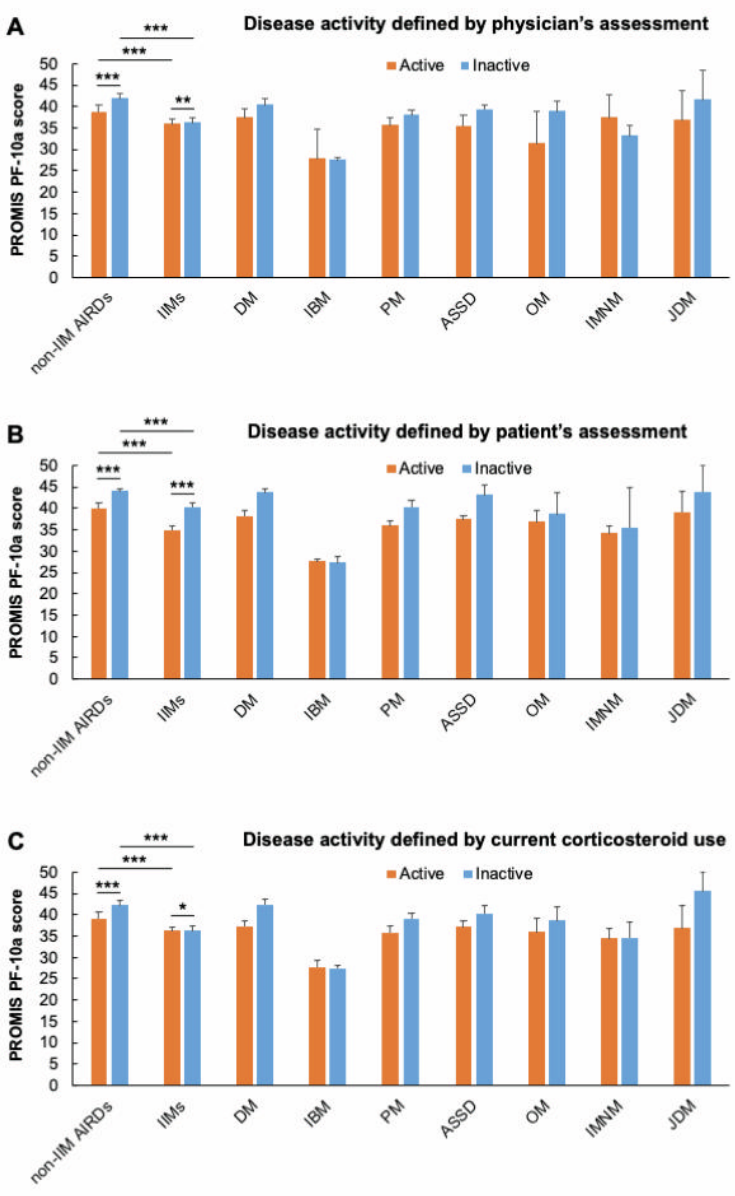

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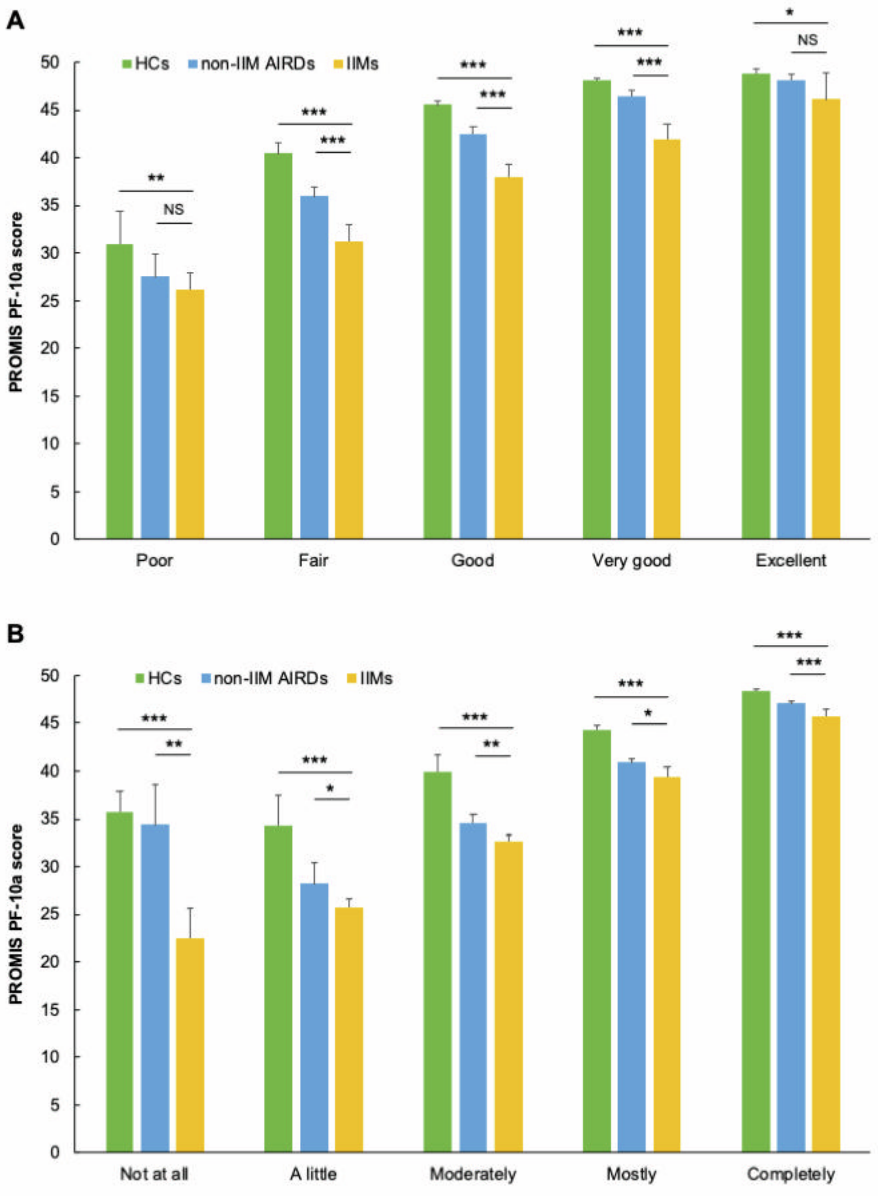

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14x19mm (1200 x 1200 DPI)