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1. INTRODUCTION

Fatigue is highly prevalent across many chronic diseases and has a profound impact on quality of life, work productivity and society.

Parkinson's Disease

50% of patients

Huntington's Disease

82,5% of patients

Rheumatoid Arthritis

75% of patients

SLE

53-80% of patients

PSS

67-87,5% of patients

IBD

40-80% of patients

Fatigue is one of the most disabling symptoms across neurological and immune-mediated diseases.

OUR OBJECTIVE:
To map questionnaire items to potential digital measures that can objectively capture fatigue in real-world settings.

2. METHODOLOGY

We performed a scoped review of the literature to identify instruments assessing fatigue and items that could be digitizable.

Literature Search

7,159
Records identified

377
Papers reviewed

48
Fatigue instruments

31
Digital measures proposed

Diseases included:

PD
Parkinson's disease

HD
Huntington's disease

RA
Rheumatoid arthritis

SLE
Systemic lupus erythematosus

PSS
Primary Sjogren's syndrome

IBD
Inflammatory bowel disease

3. RESULTS: SHARED DOMAINS OF FATIGUE AND THEIR POTENTIAL DIGITAL MEASURES

EMOTIONAL / MOTIVATIONAL FATIGUE

Questionnaire items identified

- Reduced motivation / drive
- Social withdrawal
- Reduced interests
- Emotional impact
- Routine disruption
- Feeling overwhelmed

Potential digital measures

- Social interaction frequency (calls, messages, meetings)
- Mobility / activity patterns
- Screen & app engagement
- Routine regularity (daily patterns, habits)
- Time spent at home vs out

COGNITIVE FATIGUE

Questionnaire items identified

- Difficulty concentrating
- Slower thinking
- Memory problems
- Mental effort
- Cognitive overload
- Difficulty multitasking

Potential digital measures

- Attention / vigilance (sustained attention tasks)
- Reaction time
- Memory performance
- Cognitive overload (task complexity, errors)
- Information processing speed

SLEEP / SLEEPINESS

Questionnaire items identified

- Daytime sleepiness
- Poor sleep quality
- Sleep fragmentation
- Night awakenings
- Non-restorative sleep
- Irregular sleep patterns

Potential digital measures

- Sleep duration
- Sleep efficiency
- Night awakenings
- Sleep stages
- Daytime sleep episodes
- Sleep regularity

PHYSICAL FATIGUE

Questionnaire items identified

- Reduced physical activity
- Slowness / heaviness
- Early tiredness with effort
- Need for rest / breaks
- Physical weakness
- Performance fatiguability

Potential digital measures

- Daily step count
- Gait speed & variability
- Mobility / distance travelled
- Sedentary behaviour (sitting time, breaks)
- Performance fatigability (decline across tasks)

We identified a total number of 27 different **disease-specific instruments** assessing fatigue. From these, **21 possible digitizable measures** were proposed by consensus.

4. RESULTS: DIGITAL TECHNOLOGIES TO CAPTURE FATIGUE OBJECTIVELY

WEARABLES

(accelerometers, heart rate, sleep trackers)

SMARTPHONES

(apps, sensors, usage data)

GPS

(location, mobility, movement patterns)

EYE TRACKING

(attention, visual behavior, blink rate)

EEG

(brain activity, cognitive load)

BED SENSORS

(sleep monitoring)

OTHER DIGITAL TECHNOLOGIES

(apps, digital scales, voice analysis)

These technologies can capture multiple dimensions of fatigue in real-world settings, enabling **continuous, objective and patient-independent** assessments.

5. DISCUSSION

- Fatigue manifests across four core domains that are consistent across neurological and immune-mediated diseases.
- Many items from existing questionnaires can be mapped to digital measures available today.
- Digital biomarkers of fatigue have great potential to improve measurement in clinical trials and real-world monitoring.
- Standardization and validation across diseases are next steps.

6. CONCLUSION

Our study contributes to **uncover possible novel digitizable and objective measures of fatigue**, relevant and crucial for the future development of new therapeutic strategies in the field.