

Supplementary Material

1 FLOW CHART OF STUDY PARTICIPANT INCLUSION AND EXCLUSION

Figure S1 illustrates the flow chart detailing the inclusion and exclusion applied to study participants.

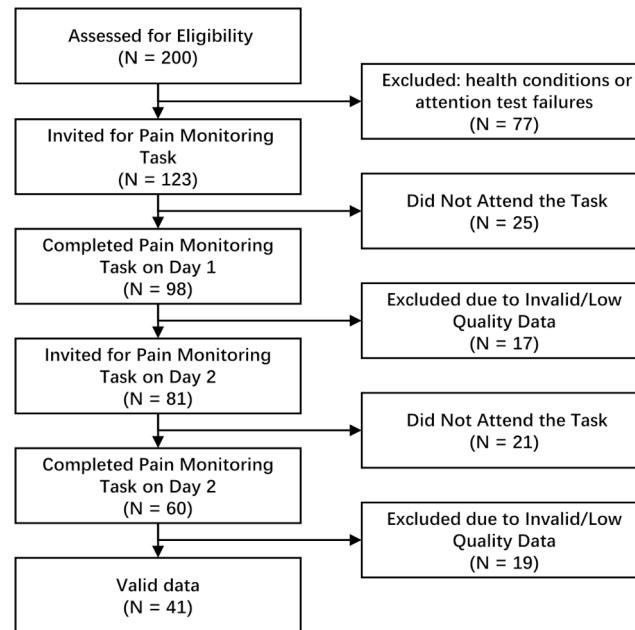


Figure S1. Flow Chart of Study Participant Inclusion and Exclusion. This flowchart illustrates the recruitment and screening process for the study. Of 200 participants recruited, 123 met the inclusion criteria based on health screening and attention checks. After Day 1, 81 participants completed the task, and 41 completed the two-day experiment, with exclusions due to non-attendance or invalid/low-quality data. Invalid or low-quality data were defined as cases where participants failed attention checks or failed to keep their finger on the screen for more than 10 seconds during the rating periods

2 VARIABILITY ANALYSES

Figure S2 presents the distribution of variability factors.

Table S1 summarizes the correlations between mean pain levels, variability measures (CV, IQR), and clinical scores to explore their clinical significance.

Table S2 presents the correlations between variability factors and prediction accuracy.

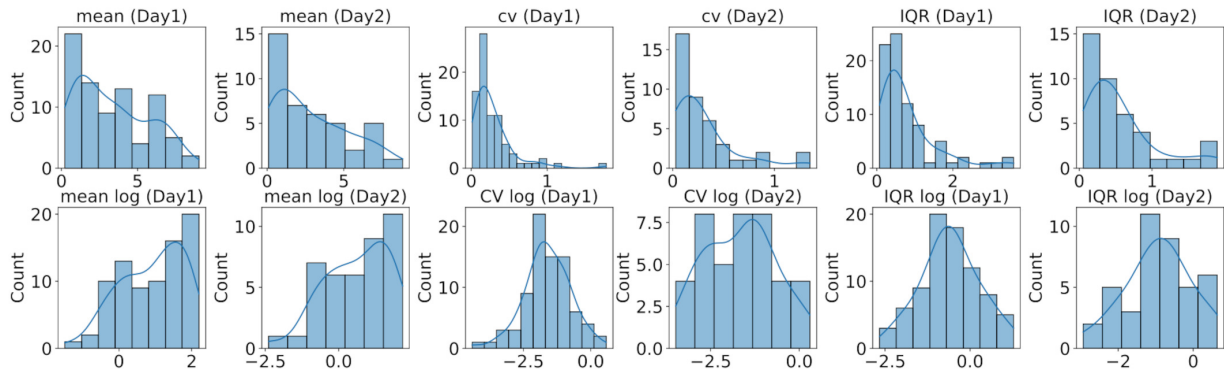


Figure S2. Distribution of Variability Factors Before and After Log Transformation. Distribution of variability factors (Mean, CV, IQR) for both Day 1 and Day 2 is displayed here. The first row represents the distribution based on raw data, while the second row depicts the distribution after log transformation. The distribution is less skewed after the log transformation.

Table S1. Significant Correlation between Variability Factors and Clinical Outcome (mean, CV, IQR v.s. MSK-HQ, BPI severity, PCS)

| | | Pearson's R | Correlation | p-value |
|--------------|--------------|-------------|-------------------|---------|
| Mean (Day 1) | MSK-HQ | -0.645 | strong negative | < 0.001 |
| Mean (Day 1) | BPI Severity | 0.752 | strong positive | < 0.001 |
| Mean (Day 1) | PCS | 0.483 | moderate positive | 0.004 |
| CV (Day 1) | MSK-HQ | 0.530 | strong positive | 0.002 |
| CV (Day 1) | BPI Severity | -0.609 | strong negative | < 0.001 |
| IQR (Day 1) | BPI Severity | 0.220 | | 0.109 |
| IQR (Day 1) | PCS | 0.299 | | 0.061 |
| Mean (Day 2) | MSK-HQ | -0.595 | strong negative | < 0.001 |
| Mean (Day 2) | BPI Severity | 0.742 | strong positive | < 0.001 |
| Mean (Day 2) | PCS | 0.537 | strong positive | 0.001 |
| CV (Day 2) | MSK-HQ | 0.485 | moderate positive | 0.002 |
| CV (Day 2) | BPI Severity | -0.634 | strong negative | < 0.001 |
| IQR (Day 2) | BPI Severity | 0.380 | moderate positive | 0.008 |
| IQR (Day 2) | PCS | 0.445 | moderate positive | 0.003 |

Table S2. Significant Correlation between Variability Factors and Prediction Accuracy (mean, CV, IQR v.s. prediction and accuracy)

| | | Pearson's R | Correlation | p-value |
|------------|------|-------------|-------------------|---------|
| prediction | Mean | 0.757 | strong positive | < 0.001 |
| prediction | CV | -0.750 | strong negative | < 0.001 |
| Accuracy | CV | -0.382 | moderate negative | 0.036 |

3 SCREENING QUESTIONNAIRE

1. How old are you?

2. What is your gender at birth?

- Male
- Female
- Prefer not to say

3. How long have you had pain to your **back** for?

- I don't have back pain
- < 1 month
- 1-3 months
- 3-6 months
- 6-12 months
- 1-2 years
- 2-5 years
- 5-10 years
- 10-20 years
- > 20 years

4. How long have you had pain to your **neck** for?

- I don't have back pain
- < 1 month
- 1-3 months
- 3-6 months
- 6-12 months
- 1-2 years
- 2-5 years
- 5-10 years
- 10-20 years
- > 20 years

5. How long have you had pain to your **legs, knees or feet** for?

- I don't have back pain
- < 1 month
- 1-3 months
- 3-6 months
- 6-12 months
- 1-2 years
- 2-5 years
- 5-10 years
- 10-20 years
- > 20 years

6. How long have you had pain to your **arms or hands** for?

- I don't have back pain
- < 1 month
- 1-3 months
- 3-6 months
- 6-12 months
- 1-2 years
- 2-5 years
- 5-10 years
- 10-20 years
- > 20 years

7. Do you identify as currently suffering from any of the following pain conditions? Please tick all that apply

- Prefer not to say
- Abdominal pain/IBS
- Arthritis (inflammatory: rheumatoid, psoriatic, etc)
- Arthritis (non-inflammatory, such as osteoarthritis)
- Complex regional pain syndrome
- Fibromyalgia
- Headache/Migraine
- Multiple Sclerosis
- Neuropathy
- Pelvic pain
- Endometriosis
- Trigeminal neuralgia
- Spinal cord injury
- stroke pain

- Other pain condition (if so, please specify below:) _____

8. Have you received a diagnosis for any of these conditions? If Yes, please provide the approximate dates of diagnoses of each condition.

- No

- Yes
Details _____

9. What treatment (pharmacological, therapy, etc), if any, are you taking for your condition(s)? Please give detail about treatment and time periods for treatment if possible.

- _____

10. Do you identify as living with, or have you received a diagnosis of any other medical condition?

- No
- Yes

If yes, please specify:

Details of condition(s) and date(s) of onset and/or diagnosis: _____

11. Do you experience any mental health difficulty? If so, how long you have experienced it, have you been diagnosed, and do you take any treatment for it? Please also provide any other details.

- _____

12. Have you ever had or are experiencing one of the following conditions? Please tick all that apply.

- Amnesia (a memory difficulty)
- Attention deficit hyperactivity disorder (ADHD)
- Brain cancer
- Brain haemorrhage
- Brain injury
- Cognitive impairment (e.g., memory, language, attention etc)
- Cognitive developmental delay
- Dementia
- Dyslexia
- Epilepsy
- Hydrocephalus
- Learning disorder
- Neurodegenerative disorder
- Stroke
- Other neurological condition: Please specify: _____
- Other cognitive condition: Please specify: _____

4 PARTICIPANT-SPECIFIC CLINICAL DETAILS VIA MSK-HQ, BPI AND PCS QUESTIONNAIRE.

| | Age | Sex | Pain Duration (year) | Type of Pain | Medical Diagnosis (If Any) |
|----|-----|--------|-------------------------|---------------------|---|
| 1 | 40 | Female | 15.00 | back pain | No |
| 2 | 30 | Female | 3.50 | back pain | No |
| 3 | 49 | Female | 7.50 | back pain | Trigeminal neuralgia (diagnosed 2010) |
| 4 | 31 | Female | 3.50 | neck pain | No |
| 5 | 54 | Female | 20.00 | back pain | Diagnosed 2022 |
| 6 | 57 | Female | 7.50 | back pain | Lumbar disc herniation(sciatic nerve) |
| 7 | 22 | Female | 3.50 | back pain | No |
| 8 | 37 | Male | 3.50 | back pain | No |
| 9 | 35 | Female | 3.50 | back pain | Irritable bowel syndrome (IBS) |
| 10 | 29 | Female | 3.50 | back pain | No |
| 11 | 32 | Female | 15.00 | back pain | No |
| 12 | 37 | Female | 15.00 | back pain | No |
| 13 | 42 | Female | 3.50 | back pain | No |
| 14 | 61 | Male | 7.50 | legs, knees or feet | No |
| 15 | 38 | Female | 3.50 | back pain | No |
| 16 | 52 | Female | 20.00 | back pain | Diagnosed Jan 2022 |
| 17 | 48 | Female | 15.00 | back pain | No |
| 18 | 58 | Female | 1.50 | legs, knees or feet | No |
| 19 | 32 | Male | 15.00 | back pain | No |
| 20 | 43 | Female | 0.75 | legs, knees or feet | No |
| 21 | 36 | Female | 7.50 | legs, knees or feet | Intraosseous cyst (ankle) |
| 22 | 52 | Female | 15.00 | back pain | Diagnosed (unspecified condition) |
| 23 | 27 | Male | 3.50 | back pain | No |
| 24 | 65 | Female | 3.50 | back pain | IBS(1985), Osteoarthritis(2012) |
| 25 | 58 | Female | 20.00 | back pain | Diagnosed 1992 |
| 26 | 54 | Female | 3.50 | arms or hands | No |
| 27 | 38 | Male | 7.50 | back pain | No |
| 28 | 46 | Male | 20.00 | neck pain | No |
| 29 | 41 | Male | 7.50 | legs, knees or feet | No |
| 30 | 50 | Female | 3.50 | legs, knees or feet | endometriosis(2021), arthritis(2020) |
| 31 | 45 | Female | 7.50 | back pain | No |
| 32 | 53 | Female | 15.00 | legs, knees or feet | No |
| 33 | 62 | Male | 3.50 | legs, knees or feet | Diagnosed 2022 |
| 34 | 41 | Female | 7.50 | back pain | No |
| 35 | 54 | Female | 20.00 | back pain | OI(birth), migraine(1990), arthritis(1988) |
| 36 | 28 | Female | 3.50 | back pain | No |
| 37 | 36 | Female | 15.00 | legs, knees or feet | DVT(2008), post-thrombotic syndrome(2020) |
| 38 | 51 | Male | 1.50 | back pain | No |
| 39 | 63 | Female | 7.50 | legs, knees or feet | Fibromyalgia, arthritis, Achilles tendinitis |
| 40 | 43 | Female | 7.50 | legs, knees or feet | Diagnosed 2016 |

| Age | Sex | Pain Duration (year) | Type of Pain | Medical Diagnosis (If Any) | |
|-----|-----|-------------------------|--------------|----------------------------|---|
| 41 | 53 | Female | 3.50 | arms or hands | No |
| 42 | 38 | Female | 15.00 | back pain | No |
| 43 | 30 | Male | 0.75 | back pain | No |
| 44 | 50 | Male | 20.00 | back pain | No |
| 45 | 44 | Female | 3.50 | back pain | diagnosed 2023; symptoms since 2017 |
| 46 | 45 | Female | 15.00 | back pain | IBS(20 years), chest pain |
| 47 | 36 | Female | 0.75 | back pain | No |
| 48 | 60 | Female | 20.00 | back pain | Diagnosed 2000 |
| 49 | 54 | Female | 7.50 | arms or hands | Diagnosed over 10 years |
| 50 | 62 | Male | 20.00 | neck pain | No |
| 51 | 52 | Male | 15.00 | legs, knees or feet | Diagnosed 2015 |
| 52 | 64 | Male | 20.00 | back pain | Diagnosed 2010 |
| 53 | 25 | Female | 7.50 | back pain | Diagnosed (unspecified condition) |
| 54 | 24 | Male | 1.50 | back pain | Diagnosed 2021 |
| 55 | 37 | Female | 15.00 | back pain | No |
| 56 | 30 | Female | 7.50 | back pain | Migraine(2018) |
| 57 | 45 | Male | 3.50 | legs, knees or feet | No |
| 58 | 64 | Male | 20.00 | neck pain | IBS diagnosed 2020; symptoms much longer |
| 59 | 62 | Female | 20.00 | neck pain | 2004 |
| 60 | 61 | Female | 15.00 | back pain | Disc herniation(lumbar, cervical), suspected RA |
| 61 | 40 | Male | 15.00 | back pain | Lumbar herniation; shoulder lesion arthritis |
| 62 | 50 | Female | 3.50 | back pain | No |
| 63 | 57 | Male | 7.50 | back pain | No |
| 64 | 38 | Male | 7.50 | back pain | No |
| 65 | 47 | Female | 7.50 | back pain | Lower back injury (2016), diagnosed 2018 |
| 66 | 58 | Female | 20.00 | back pain | CBP(1980), IBS(2000), diverticulitis(2000s) |
| 67 | 64 | Female | 3.50 | back pain | Diagnosed 2019 |
| 68 | 42 | Female | 3.50 | legs, knees or feet | No |
| 69 | 36 | Male | 7.50 | back pain | No |
| 70 | 33 | Female | 1.50 | back pain | No |
| 71 | 29 | Female | 15.00 | back pain | Diagnosed 2008 |
| 72 | 55 | Male | 20.00 | back pain | Diagnosed 2008 |
| 73 | 56 | Female | 15.00 | back pain | Osteoarthritis(2013) |
| 74 | 48 | Female | 3.50 | back pain | Diagnosed 2021 |
| 75 | 26 | Female | 3.50 | back pain | No |
| 76 | 52 | Female | 20.00 | legs, knees or feet | ME (1995) |
| 77 | 36 | Male | 7.50 | back pain | Diagnosed 2020 |
| 78 | 51 | Female | 20.00 | back pain | Diagnosed 2003 |
| 79 | 63 | Female | 3.50 | legs, knees or feet | Knee arthritis (2021, bilateral) |
| 80 | 42 | Female | 15.00 | back pain | endometriosis(1999), calcification(2022) |
| 81 | 61 | Female | 3.50 | legs, knees or feet | No |

Pain Medication Taken (If Any)

- 1 OTC pain relievers
 - 2 none
 - 3 Pregabalin
 - 4 Pain relievers
 - 5 Amitriptyline 30 mg daily; tramadol (occasional use)
 - 6 Nortriptyline, nightly
 - 7 Ibuprofen as needed
 - 8 Pain relievers
 - 9 Dietary modifications and antacids for IBS; physical therapy and exercise for back pain
 - 10 None
 - 11 Pain relievers as needed; prefers stretching exercises
 - 12 Pain relievers (occasional use)
 - 13 Physiotherapy: 1 session/month; 3 sessions received to date
 - 14 Non-prescription anti-inflammatory tablets; arm/hand exercises
 - 15
 - 16 Chiropractor for 6 months; Physiotherapy for 2 months
 - 17 Sports Physio for back pain
 - 18 paracetamol, ibuprofen, as needed
 - 19 No formal treatment; exercises to strengthen back muscles
 - 20 Pain relievers
 - 21
 - 22 Amitriptyline for nerve pain, paracetamol and ibuprofen
 - 23 Physiotherapeutic exercises
 - 24 Monthly massage; occasional Reiki; regular exercise; topical natural oil gel for joints
 - 25 Aspirin, paracetamol, and topical anti-inflammatory gel for back and shoulder pain
 - 26 Vitamins and mineral supplements; exercise; heat therapy
 - 27
 - 28 none
 - 29 Stretching, yoga, walking
 - 30 Progesterone for endometriosis; non-opioid analgesics for hip and knee pain
 - 31
 - 32 Co-codamol and paracetamol; naproxen discontinued due to side effects
 - 33 Pain relievers
 - 34 Codeine (as needed)
 - 35 Morphine, Gabapentin, Amitriptyline
 - 36 none
 - 37 Blood thinners and compression tights
 - 38 Ibuprofen as needed; physiotherapy and chiropractic treatment
 - 39 codeine, Amitriptyline and Citalopram
 - 40 Methotrexate injections (weekly)
-

Pain Medication Taken (If Any)

- 41 Pain relievers and anti-inflammatory medications
 - 42 Chiropractor every 6 weeks
 - 43
 - 44 Back massage 2-3 times/year
 - 45 Sertraline for pain management
 - 46 Lansoprazole
 - 47
 - 48 simple pain relievers like paracetamol
 - 49 Metamucil(IBS); massage, physiotherapy, and extra-strength Tylenol(shoulder pain);
shoulder surgery
 - 50 none
 - 51 Meloxicam tablets; meditation; home heat therapy
 - 52 Statins and aspirin
 - 53 Pain relievers as needed, used intermittently since onset of pain
 - 54 Propranolol
 - 55
 - 56 Prescribed medication
 - 57 Regular stretching and exercise
 - 58 OTC remedies (charcoal, probiotics, gas relief)
 - 59 Discontinued Celebrex; currently uses muscle relaxants as needed and occasional
ibuprofen
 - 60 Previously used strong pain meds; now rarely uses OTC analgesics
 - 61 Naproxen and omeprazole
 - 62 Physiotherapy (past)
 - 63 Paracetamol
 - 64 Ibuprofen as needed
 - 65 PRN analgesics (paracetamol, ibuprofen); physiotherapy, stretching, and yoga several
times/week
 - 66 Co-codamol (intermittent), mirtazapine, amitriptyline (long-term)
 - 67 Steroids
 - 68 OTC pain relievers
 - 69 Regular physiotherapy
 - 70 Massage therapy
 - 71 Physiotherapy and chiropractic treatment
 - 72 Humira, methotrexate, tramadol
 - 73 Steroid injections (2015–2018); dihydrocodeine, paracetamol, gabapentin (ongoing)
 - 74 Anti-inflammatories as needed
 - 75 Pain medication (ibuprofen), no other treatment
 - 76
 - 77 Spinal injections
 - 78 Medication and exercise
 - 79 Physiotherapy (initial treatment)
 - 80 pain relievers
 - 81 OTC pain relievers
-

| MSK-HQ | | BPI Severity | BPI Interference | PCS Rumination | PCS Magnification | PCS Helplessness |
|--------|----|-----------------|---------------------|-------------------|----------------------|---------------------|
| 1 | 43 | 4.50 | 2.57 | | | |
| 2 | 43 | 3.25 | 3.00 | 12.00 | 3.00 | 3.00 |
| 3 | 22 | | | 4.00 | 3.00 | 7.00 |
| 4 | 38 | 2.00 | 1.00 | 4.00 | 2.00 | 5.00 |
| 5 | 27 | 4.50 | 3.57 | 8.00 | 3.50 | 9.50 |
| 6 | 35 | 3.25 | 8.29 | | | |
| 7 | 33 | 5.00 | 6.14 | 4.00 | 5.00 | 8.00 |
| 8 | 44 | | | | | |
| 9 | 36 | 6.50 | 4.71 | 2.00 | 1.00 | 1.00 |
| 10 | 41 | | | 3.00 | 2.00 | 2.00 |
| 11 | 22 | 6.75 | 7.43 | 7.00 | 7.00 | 10.00 |
| 12 | 44 | 2.00 | 1.29 | 2.00 | 3.00 | 2.00 |
| 13 | 35 | 4.00 | 7.29 | | | |
| 14 | 38 | | | 6.00 | 3.00 | 9.00 |
| 15 | 35 | 3.75 | 3.00 | 5.00 | 3.00 | 7.00 |
| 16 | 37 | 3.75 | 4.43 | 10.00 | 9.00 | 12.00 |
| 17 | 39 | | | 5.00 | 2.00 | 4.00 |
| 18 | 44 | 1.50 | 0.29 | 0.00 | 0.00 | 0.00 |
| 19 | 43 | 2.50 | 0.71 | 0.00 | 2.00 | 2.00 |
| 20 | 44 | 5.00 | 1.43 | 3.00 | 1.00 | 4.00 |
| 21 | 43 | 1.25 | 0.14 | 0.00 | 2.00 | 0.00 |
| 22 | 45 | | | 5.00 | 5.00 | 7.00 |
| 23 | 40 | 2.25 | 0.43 | 1.00 | 0.00 | 1.00 |
| 24 | 48 | 2.25 | 1.71 | 3.00 | 0.00 | 1.00 |
| 25 | 43 | 6.25 | 2.00 | 6.00 | | 2.00 |
| 26 | 50 | 4.50 | 4.14 | 1.00 | 1.00 | 2.00 |
| 27 | 40 | 2.75 | 3.00 | 5.00 | 3.00 | 8.00 |
| 28 | 36 | 5.25 | 6.71 | 4.00 | 5.00 | 9.00 |
| 29 | 42 | 5.25 | 5.14 | 4.00 | 1.00 | 5.00 |
| 30 | 24 | 3.75 | 4.86 | 12.00 | 7.00 | 14.00 |
| 31 | 24 | 4.00 | 4.71 | 6.00 | 5.00 | 7.00 |
| 32 | 14 | 5.75 | 7.29 | 12.00 | 9.00 | 14.00 |
| 33 | 34 | 5.00 | 4.86 | 5.00 | 4.00 | 4.00 |
| 34 | 50 | 2.50 | 2.86 | 0.00 | 1.00 | 0.00 |
| 35 | 21 | | | 4.00 | 2.00 | 5.00 |
| 36 | 41 | 2.75 | 2.43 | | | |
| 37 | 35 | 2.25 | 2.14 | 3.00 | 3.00 | 1.00 |
| 38 | 42 | 2.75 | 0.57 | | | |
| 39 | 32 | 4.25 | 5.86 | 3.00 | 2.00 | 6.00 |
| 40 | 31 | 4.00 | 4.71 | 6.00 | 5.00 | 7.00 |

| MSK-HQ | | BPI Severity | BPI Interference | PCS Rumination | PCS Magnification | PCS Helplessness |
|--------|----|-----------------|---------------------|-------------------|----------------------|---------------------|
| 41 | 24 | 6.50 | 5.43 | 10.00 | 4.00 | 12.00 |
| 42 | 46 | | | 2.00 | 1.00 | 1.00 |
| 43 | 45 | 1.25 | 0.29 | 0.00 | 1.00 | 1.00 |
| 44 | 26 | 2.00 | 2.86 | | | |
| 45 | 26 | 6.75 | 6.43 | 12.00 | 12.00 | 14.00 |
| 46 | 34 | | | | | |
| 47 | 45 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| 48 | 45 | 2.25 | 0.29 | 4.00 | 4.00 | 4.00 |
| 49 | 17 | 6.50 | 4.00 | 6.00 | 5.00 | 13.00 |
| 50 | 47 | | | | | |
| 51 | 28 | 4.75 | 6.86 | 9.00 | 7.00 | 13.00 |
| 52 | 38 | 2.25 | 1.71 | 11.00 | 0.00 | 7.00 |
| 53 | 32 | 3.25 | 2.00 | 7.00 | 4.00 | 8.00 |
| 54 | 33 | 7.00 | 3.71 | 8.00 | 8.00 | 6.00 |
| 55 | 29 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 56 | 40 | 2.50 | 1.71 | 3.00 | 1.00 | 3.00 |
| 57 | 40 | 3.00 | 0.71 | 0.00 | 1.00 | 2.00 |
| 58 | 50 | 2.50 | 1.14 | 5.00 | 1.00 | 3.00 |
| 59 | 40 | 5.25 | 1.43 | | | |
| 60 | 38 | 4.50 | 1.29 | 0.00 | 3.00 | 2.00 |
| 61 | 38 | 4.50 | 2.29 | 1.00 | 2.00 | 3.00 |
| 62 | 48 | 1.00 | 0.43 | 0.00 | 0.00 | 1.00 |
| 63 | 50 | 2.00 | 1.71 | 2.00 | 0.00 | |
| 64 | 42 | 1.75 | 2.29 | 2.00 | 1.00 | 1.00 |
| 65 | 40 | 4.75 | 2.57 | | | |
| 66 | 21 | 7.00 | 7.43 | 6.00 | 3.00 | 8.00 |
| 67 | 46 | 3.25 | 3.14 | | | |
| 68 | 42 | 2.00 | 0.57 | 4.00 | 2.00 | 2.00 |
| 69 | 38 | 3.00 | 5.29 | 4.00 | 5.00 | 6.00 |
| 70 | 44 | 3.00 | 2.86 | 8.00 | 4.00 | 3.00 |
| 71 | 35 | | | 9.50 | 4.50 | 10.00 |
| 72 | 9 | 4.25 | 7.57 | 15.00 | 8.00 | 21.00 |
| 73 | 16 | 8.00 | 9.00 | 13.00 | 11.00 | |
| 74 | 37 | 4.25 | 6.00 | 10.00 | 5.00 | 13.00 |
| 75 | 42 | 5.25 | 4.57 | 3.00 | 1.00 | 5.00 |
| 76 | 45 | 4.50 | 5.43 | 2.00 | 1.00 | 5.00 |
| 77 | 41 | 4.50 | 1.86 | 4.00 | 2.00 | 7.00 |
| 78 | 31 | | | 7.00 | 1.00 | 7.00 |
| 79 | 36 | 2.75 | 2.71 | | | |
| 80 | 29 | 4.75 | 5.00 | 6.00 | 4.00 | 6.00 |
| 81 | 35 | 2.75 | 2.29 | | | |