

# Discharge Cognitive–Motor Imbalance Patterns and Long-Term Outcomes After Traumatic Brain Injury: A Propensity Score–Matched Cohort Study

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## 1. Background & Objectives

### Why this study?

TBI is a leading cause of long-term disability worldwide, imposing substantial burden on individuals and healthcare systems. Recovery across cognitive and motor domains is highly heterogeneous, yet composite discharge measures such as total functional independence measure (FIM) score may obscure meaningful within-person imbalances — patients with similar overall scores can have markedly different cognitive–motor profiles. Whether such discharge-level discrepancies carry independent prognostic value beyond overall severity remains unclear.

**This study aimed to:** 1) classify cognitive–motor imbalance patterns, 2) compare 1 & 2-year outcomes, and 3) explore severity subgroups.

### Exposure (Cognitive–Motor Imbalance)

• FIM subscales each rescaled 0–100;  
**Standardized discrepancy = (FIM-cognitive – FIM-motor) / SD**  
**Cognitive-dominant**  $\geq +0.15$  SD / **Motor-dominant**  $\leq -0.15$  SD / **Balanced**  $\pm 0.15$  SD

### Primary & Secondary Outcomes

• **Primary:** DRS (0–29) continuous & DRS  $\leq 3$  binary → at 1 year & 2 yrs  
 • **Secondary:** FIM total / FIM motor / FIM cognitive → at 1 year & 2 yrs

\* DRS: Disability Rating Score, FIM: Functional Independence Measure

## 2. Methods

### Study Design

• **Retrospective cohort study**  
 • **Adults ( $\geq 16$  yr)** with moderate-to-severe TBI; FIM motor & cognitive available at discharge (n=8,342 before matching)

### Data Source

• **TBIMS National Database** (multicenter USA, public dataset released Nov 2025)

### Propensity Score Matching (PSM)

• Balanced group as common reference  
 • Two separate logistic PS models (cognitive-dominant vs. balanced; motor-dominant vs. balanced) 1:2 nearest-neighbor matching without replacement; caliper =  $0.25 \times$ SD of logit (PS)  
 • Balance assessed by |SMD| $<0.10$

### Covariates

Age, sex, race/ethnicity, marital status, education level, employment status, injury mechanism, admission GCS score, history of problematic alcohol use, and discharge FIM total score — included in both PS models and outcome regression models

### Statistical Analysis

• Linear regression for continuous outcomes (DRS, FIM)  
 • Logistic regression for binary outcome (DRS  $\leq 3$ )  
 • Stratified analyses by discharge DRS and FIM strata treated as exploratory  
 • R v4.3.3 / MatchIt package

## 3. Participant Characteristics & Results

262

Balanced

524

Cognitive Dominant

524

Motor Dominant

After 1:2 propensity score matching — all |SMD|  $< 0.10$   
 (excellent covariate balance)

Table 1. Baseline Characteristics After Propensity Score Matching

| Variable                | Balanced (n=262) | Cog-Dominant (n=524) | Motor-Dominant (n=524) | SMD   |
|-------------------------|------------------|----------------------|------------------------|-------|
| Age, years              | 42.9 $\pm$ 19.5  | 42.6 $\pm$ 19.2      | 43.1 $\pm$ 18.2        | 0.017 |
| Sex, male, n (%)        | 169 (64.5)       | 342 (65.3)           | 347 (66.2)             | 0.024 |
| Race, n (%)             |                  |                      |                        |       |
| White                   | 184 (70.2)       | 367 (70.0)           | 359 (68.5)             | 0.050 |
| Black                   | 47 (17.9)        | 92 (17.6)            | 106 (20.2)             |       |
| Others                  | 31 (11.8)        | 65 (12.4)            | 59 (11.3)              |       |
| Marital status, n (%)   |                  |                      |                        |       |
| Single                  | 114 (43.5)       | 223 (42.6)           | 235 (44.8)             | 0.031 |
| Married                 | 94 (35.9)        | 191 (36.5)           | 184 (35.1)             |       |
| Previously married      | 54 (20.6)        | 110 (21.0)           | 105 (20.0)             |       |
| Education, n (%)        |                  |                      |                        |       |
| Low                     | 29 (11.1)        | 54 (10.3)            | 68 (13.0)              | 0.063 |
| Middle                  | 109 (41.6)       | 228 (43.5)           | 213 (40.6)             |       |
| High                    | 124 (47.3)       | 242 (46.2)           | 243 (46.4)             |       |
| Employed, n (%)         | 163 (62.2)       | 327 (62.4)           | 318 (60.7)             | 0.024 |
| Mechanism of injury (%) |                  |                      |                        |       |
| Motor vehicle accident  | 121 (46.2)       | 256 (48.9)           | 237 (45.2)             | 0.048 |
| Fall                    | 75 (28.6)        | 145 (27.7)           | 150 (28.6)             |       |
| Assault                 | 30 (11.5)        | 50 (9.5)             | 59 (11.3)              |       |
| GCS total               | 11.0 $\pm$ 4.3   | 11.0 $\pm$ 4.3       | 11.2 $\pm$ 3.9         | 0.034 |
| Alcohol history, n (%)  | 168 (64.1)       | 340 (64.9)           | 335 (63.9)             | 0.013 |
| FIM total at discharge  | 91.8 $\pm$ 27.1  | 90.6 $\pm$ 19.5      | 93.0 $\pm$ 19.7        | 0.074 |

Table 2. Primary and Secondary Outcomes for Functional Recovery

Reference: balanced group.  $\beta$ : linear regression; OR: logistic regression (DRS  $\leq 3$ )  
 Green = cognitive-dominant significant; Orange = motor-dominant significant

| Outcome | Cognitive Dominant $\beta$ or OR (95% CI) | p                           | Motor Dominant $\beta$ or OR (95% CI) | p                        |                     |
|---------|---|-----------------------------|---------------------------------------|--------------------------|---------------------|
| DRS     | DRS, 1yr                                  | <b>-0.45 (-0.81, -0.09)</b> | <b>0.02</b>                           | -0.10 (-0.46, 0.26)      | 0.60                |
|         | DRS, 2yr                                  | <b>-0.40 (-0.78, -0.03)</b> | <b>0.03</b>                           | 0.07 (-0.31, 0.44)       | 0.72                |
|         | DRS $\leq 3$ , 1yr (OR)                   | 1.17 (0.78, 1.75)           | 0.45                                  | 0.84 (0.56, 1.26)        | 0.40                |
|         | DRS $\leq 3$ , 2yr (OR)                   | 0.69 (0.40, 1.17)           | 0.17                                  | <b>0.52 (0.31, 0.88)</b> | <b>0.01</b> ↓*      |
| FIM     | FIM total, 1yr                            | <b>3.05 (1.11, 4.99)</b>    | <b>0.002</b>                          | <b>2.81 (0.87, 4.76)</b> | <b>0.005</b> ↑**    |
|         | FIM total, 2yr                            | <b>2.05 (0.06, 4.04)</b>    | <b>0.04</b>                           | 1.62 (-0.36, 3.61)       | 0.11 ↑*             |
|         | FIM cognitive, 1yr                        | <b>1.07 (0.46, 1.69)</b>    | <b>&lt;.001</b>                       | -0.61 (-1.23, 0.01)      | 0.05 ↑**            |
|         | FIM cognitive, 2yr                        | <b>0.92 (0.32, 1.52)</b>    | <b>0.002</b>                          | -0.59 (-1.19, 0.01)      | 0.05 ↑**            |
|         | FIM motor, 1yr                            | <b>2.00 (0.48, 3.52)</b>    | <b>0.01</b>                           | <b>3.37 (1.85, 4.89)</b> | <b>&lt;.001</b> ↑** |
|         | FIM motor, 2yr                            | 1.14 (-0.43, 2.71)          | 0.16                                  | <b>2.22 (0.85, 3.59)</b> | <b>0.002</b> ↑**    |

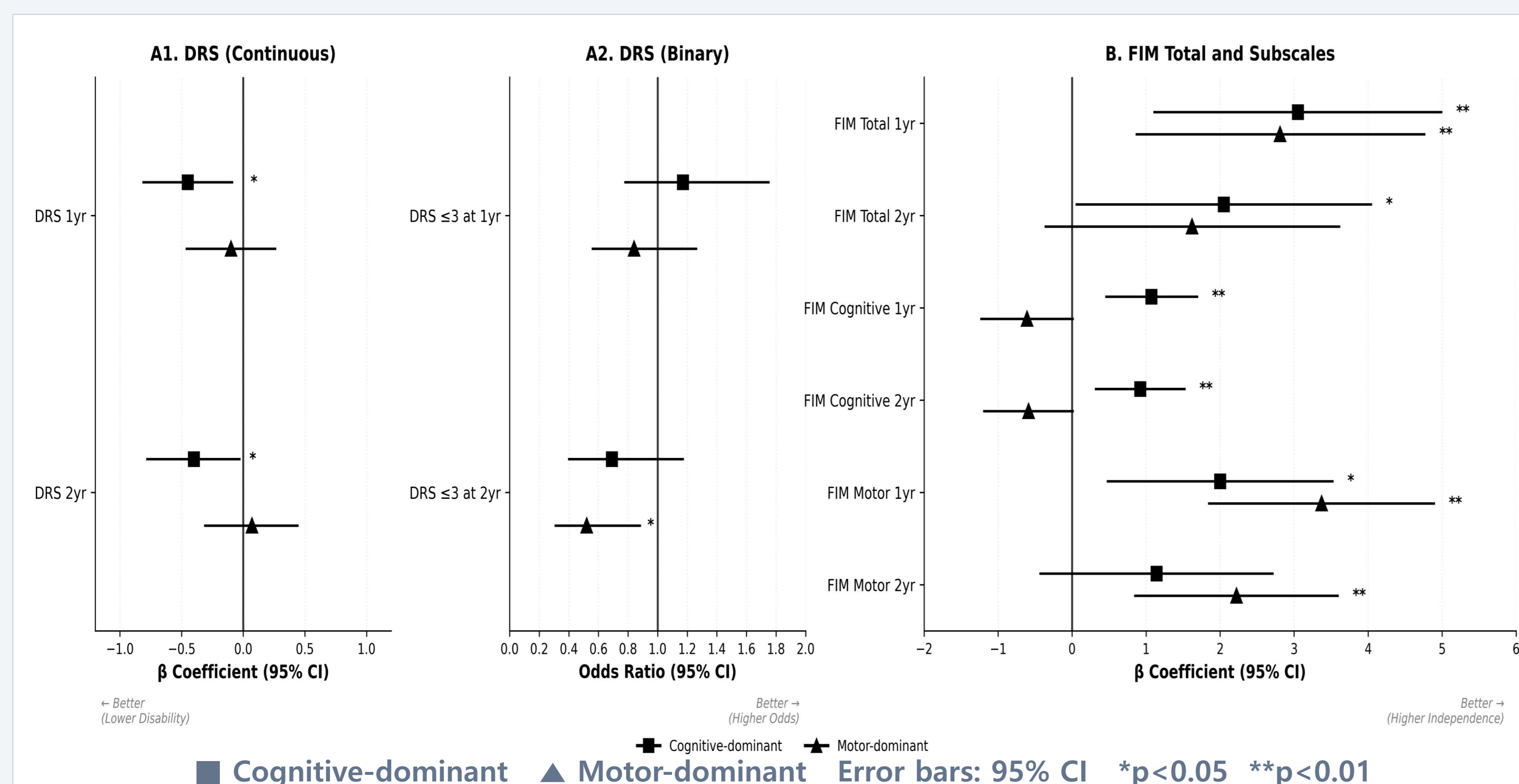


Figure 1. Adjusted associations of discharge cognitive–motor imbalance patterns with 1-year and 2-year outcomes

Reference: Balanced group  
 • Panel A1: continuous DRS ( $\beta$ ; negative = lower disability = better)  
 • Panel A2: DRS  $\leq 3$  (OR;  $>1$  = favorable)  
 • Panel B: FIM total and subscales ( $\beta$ ; positive = greater independence = better)

### • Cognitive-dominant pattern

• Lower DRS at 1 and 2 years, and higher FIM total and FIM cognitive scores

### • Motor-dominant pattern

• Lower odds of favorable disability status (DRS  $\leq 3$ ) at 2 years

## 4. Summary & Discussion

### • Cognitive-dominant pattern

• Preserved cognition at discharge supports long-term functional recovery, possibly through cognitive reserve mechanisms

### • Motor-dominant pattern

• Lower odds of favorable disability indicates 'hidden' cognitive vulnerability despite strong motor performance

• **GOSE & PART-O (exploratory):** No significant differences across groups

### • Clinical implication

• Cognitive–motor imbalance phenotype provides **additional prognostic context** beyond global discharge severity

• Identifying motor-dominant individuals may support targeted discharge planning, caregiver education, and neuropsychological follow-up referral

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