Results

# Sample Descriptives

Sociodemographic characteristics of the sample and frequency of eating disorder diagnosis groups are presented in [Table 1](#tbl-tbl1)

Table 1: Sample Descriptives

| \*\*Variable\*\* | \*\*N = 7,259\*\* |
| --- | --- |
| \_\_Ethnicity\_\_ | NA |
| Hispanic | 591 (8.1) |
| Non-Hispanic | 6,668 (91.9) |
| \_\_Gender Identity\_\_ | NA |
| Man | 327 (4.5) |
| Woman | 6,432 (89.0) |
| Nonbinary | 471 (6.5) |
| Unknown | 29 |
| \_\_Biological Sex\_\_ | NA |
| Male | 272 (3.7) |
| Female | 6,987 (96.3) |
| Intersex | 0 (0.0) |
| \_\_Race\_\_ | NA |
| White | 6,526 (89.9) |
| Black | 177 (2.4) |
| Asian | 186 (2.6) |
| Other | 370 (5.1) |
| \_\_Age\_\_ | 33.66 (12.61) |
| \_\_Current BMI\_\_ | 26.54 (11.36) |
| \_\_Eating Disorder Diagnosis\_\_ | NA |
| AN | 3,023 (41.6) |
| AN Mixed | 1,629 (22.4) |
| BED | 661 (9.1) |
| BN | 898 (12.4) |
| BN-BED Mixed | 1,048 (14.4) |

# Preliminary Aim - Develop a scoring algorithm

Our first aim is to evaluate the uniqueness of various scoring approaches for ED100k exercise items to define maladaptive exercise history among individuals with EDs using this self-report measure. We specifically aim to optimize a set of items and scoring approach(es), derived from the original 12 ED100k exercise history items, which *most concisely* captures varying conceptualizations of maladaptive exercise history that are commonly present in EDs, including:

1. A single-item assessment of *any* maladaptive exercise history (broad definition)
2. A single-item assessment of a history of *regular* engagement in maladaptive exercise (narrow definition)
3. Maladaptive exercise history with verified compulsive feature(s) (consistent with definitions of ‘compulsive & driven exercise’)
4. Maladaptive exercise that has occurred regularly and interfered with life or health (consistent with definitions of ‘addictive exercise & exercise dependence’)
5. Maladaptive exercise that has occurred very frequently for a period of time (e.g. almost every day for a period of at least one month; consistent with definitions of ‘excessive exercise’)
6. Exercise that is used to compensate for binge eating or overeating (consistent with definitions of ‘compensatory exercise’)
7. Current Maladaptive Exercise Engagement

We will focus on evaluation of the incremental validity of scoring approaches and accompanying items beyond a single-item measure (Q1) of maladaptive exercise history. Based on results, we will refine a set of items and scoring approach(es) for examination of convergent and discriminant validity (Aim 2) and estimation of prevalence across diagnostic groups (Aim 3).

## Scoring

The ED100k included 12 questions assessing maladaptive exercise. The first question, which all participants were asked, inquires as to whether individuals *ever* exercised to intentionally control weight and shape (Q1). Only those who endorsed EVER Exercising to intentionally control weight or shape were asked to respond to two additional questions which asked about exercise in more detail, including two questions (Q2, Q3) about whether individuals ever felt compelled to exercise and whether they felt uneasy or distressed if unable to exercise. In a third step, those who reported affirmatively to Q1 and ‘Yes’ to *either* Q2 or Q3 were additionally asked three questions (Q4-Q6) about whether exercise interfered with life activities or diet, along with questions regarding the onset (Q7), duration (Q8), and frequency (Q9) of their maladaptive exercise, along with whether they engaged in the behavior currently (Q10) and the last age at which they engaged in the behavior (Q11). In a separate section, all participants were asked whether they had ‘exercised excessively’ specifically to *compensate* for episodes of binge eating or overeating (Q12). During recoding, those (n = 945) who reported no to Q1 were marked as ‘0’ for all follow-up questions, with the exception of ages (Q10-11), which were retained as missing. Those who reported that they had engaged in exercise to for weight and shape control but ‘No’ to both Q2 & Q3 (n = 200) were marked as ‘0’ for Q4-Q9. Frequencies for the 10 dichotomous/ordinal exercise items with imputed values based on skip patterns (see [scoring](sec:scoring)) are provide in Supplemental [Table 8](#tbl-ed100kItems). Median age of onset for those reporting any compulsive exercise in the sample was 16 years and the median age of last report of compulsive exercise was 26 years. Among those who reported any compulsive exercise, 52.28% reported that this was an ongoing symptom.

Scoring algorithms for each subconstruct are presented in [Table 2](#tbl-defs).

Table 2: Algorithm defining exercise-related constructs in the ED100k

|  |  |  |
| --- | --- | --- |
| **Scoring Approach** | **Criteria** | **Nested Within** |
| 1. ‘Q1 Broad’ | Participant endorses that they have exercised excessively (e.g. felt compelled to exercise, felt uneasy or distressed if unable to exercise) to control weight or shape ‘A few times’ or more | NA |
| 1. ‘Q1 Narrow’ | Participant endorses that they have exercised excessively (e.g. felt compelled to exercise, felt uneasy or distressed if unable to exercise) to control weight or shape ‘more often’ | 1 |
| 1. ‘Driven/Compulsive Exercise Broad’ (Q1 Validation) | Q1 Broad (#1)  Ever felt compelled to exercise == ‘YES’ OR Ever uneasy or distressed when unable to exercise == ‘YES’ | 1 |
| 1. ‘Driven/Compulsive Exercise Narrow’ (Q1 Validation) | Q1 Narrow (#1, #2)  Ever felt compelled to exercise == ‘YES’ OR Ever uneasy or distressed when unable to exercise == ‘YES’ | 1, 2 |
| 1. ‘Addictive Exercise’ | Q1 Narrow (#1,#2)  Driven/Compulsive symptom verified (#3)  Duration >= 3 months  1 or more of the following:  -caused to change eating habits  -decline opportunities to be with friends  -exercised despite illness or injury | 1, 2, 3 |
| 1. ‘Excessive Exercise’ | Q1 Narrow (#1,#2)  Driven/Compulsive symptom verified (#3)  Duration >= 1 month  Frequency = ‘Every Day’ or ‘Nearly Every Day’ | 1, 2, 3 |
| 1. ‘Compensatory Exercise’ | Have you ever used any of the following to compensate for episodes of binge eating or overeating? (Mark all that apply) (choice=Exercised excessively (e.g., felt compelled to exercise, felt uneasy or distressed if unable to exercise)) | NA |
| 1. ‘**Current** Maladaptive Exercise’ | Q1 Broad (#1)  Driven/Compulsive symptom verified  Do you *currently* exercise to control weight and shape AND  Feel compelled to exercise OR distress if unable to exercise? == ‘YES’ | 1, 3 |

# Aim 1. Evaluate patterns of response across multiple scoring methods – to identify the degree to which scoring methods requiring different item-level endorsement, consistent with varying definitions of maladaptive exercise, result in overlapping membership or capture distinct groups

We hypothesize that Q1 Broad (Approach #1) will have high positive predictive value (PPV; > 0.80) for broad compulsive exercise (Q1 compulsive symptom verification, Approach #3), moderate PPV (>0.50) for Q1 Narrow (#2) along with approaches nested within Q1 Narrow (regular compulsive exercise (#4), addictive exercise (#5), and excessive exercise (#6)). and moderate PPV for compensatory exercise (#7). As individuals in the sample range in ED recovery status, we expect Q1 Broad to have a low PPV ( <0.40) for current maladaptive exercise (#8).

We hypothesize that Q1 Narrow (Approach # 2) will be likely to meet criteria for compulsive exercise (#3), regular compulsive exercise (#4) exercise addiction (#5), and excessive exercise (#6) (high PPV; > 0.80), and moderately likely to meet criteria for compensatory exercise (#7) (moderate PPV; > 0.50). As many individuals in the sample are in ED recovery, we expect Q1 Broad to have a low PPV for current maladaptive exercise (#8; < 0.40).

[Figure 1](#fig-heatmap) presents the proportion of the full sample along with sub-samples (horizontal axis) meeting criteria for each (sub)construct (vertical axis).

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| Figure 1: Heatmap presenting the positive predictive value (PPV\*100) as the percentage of (sub)samples (horizontal axis) meeting criteria for each (sub)construct (vertical axis) |

## Accuracy of Q1 (Approaches 1-2) to detect further maladaptive exercise symptoms

Overall, there was high convergent validity for Q1 with Q2-Q6. Specifically, individuals eating disorders who endorse Q1 Broad (Approach #1) are highly likely to confirm either feeling compelled to exercise or distressed when unable to exercise (#3; high PPV). As hypothesized, Q1 Broad (#1) had more moderate PPV for approaches #4-7 (compulsive/driven [narrow], addictive, excessive, compulsive).

Among those meeting Q1 Narrow (#2), individuals were likely to engage in this behavior for a substantive period of time – 98.2% of those meeting Q1 Narrow reported maladaptive exercise for a duration of > 3 months; a time period of equivalent to diagnostic levels of other intentional weight control behaviors. Those meeting Q1 Narrow were also highly likely to report symptoms consistent with definitions of both compulsive/driven (high PPV for #3-4), addictive (high PPV for #5) exercise. Q1 Narrow PPV for predicting excessive exercise (#6) was also high (>0.80), but less so than approaches #3-5.

[Figure 2](#fig-Q1sensitivity-USA) reports full metrics on the utility of Q1 Broad and Q1 Narrow to capture definitions in approaches #3-8. The sensitivity and negative predictive values of Q1 Broad detection of approaches #3-6 were forced to 1.0 by definition. Overall accuracy metrics of Q1 Broad predicting #3, and Q1 Narrow predicting #4-5 suggest that additional criteria added to these approaches are not necessary for defining maladaptive exercise that (1) verifies compulsive/driven symptoms and (2) identifies significant duration and interference with life and/or health among individuals with EDs. Overall, the vast majority of individuals with eating disorders who reporting regular exercise for weight loss to control weight and shape in Q1 go on to report that this exercise was compulsive and that they also experienced life interfering sequelae of this behavior. Further, regarding specific addictive exercise symptoms, the modal number of exercise interference items was all 3.

While Q1 accurately defined those experiencing compulsive and addictive exercise (Approaches #3-5) with little additional information provided from follow-up questions, the same was not true for excessive exercise (#6) and compensatory exercise (#7) – additional questions may be necessary to define excessive and compensatory exercise with the highest levels of accuracy, and endorsement of these constructs do not entirely overlap with endorsement of other maladaptive exercise symptoms. While PPV and overall accuracy for Q1 Broad predicting compensatory accuracy (#7) were moderate, suggesting that not all individuals who endorse Q1 Broad also endorse compensatory exercise, sensitivity was high – almost all of those who endorsed compensatory exercise also endorsed Q1 Broad. Overall accuracy of both Q1 Broad and Q1 Narrow in predicting compensatory exercise (#7) was moderate, again suggesting that compensatory exercise occurs in only a subsample of those with maladaptive exercise, and that this question provides utility in the scale. For further analysis in Aims 2-3, scoring approaches #1,2,6,7, & 8 are retained, as they provide unique and discriminable information about maladaptive exercise patterns.

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| Figure 2: Accuracy of Q1 Broad (#1) and Q1 Narrow (#2) in detecting groups defined in approaches #3-8 |

# Aim 2. Evaluate Convergent and Discriminant Validity between ED100k Scoring Approaches and: Current Compulsive Exercise, Perfectionism, and OCD symptoms

H2a: Individuals who do meet Q1 Broad (#1), Q1 Narrow (#2), or Current Maladaptive Exercise (#8), will not report current compulsive/driven exercise (high negative predictive value [NPV]; *>90% for 1. Current driven exercise to manage weight/shape on the EDEQ, 2. Current compulsive exercise at clinical cutoff on the CET).* NPV will be lower for Excessive Exercise (#6) and compensatory exercise (#7), as these operationalizations capture smaller subsamples which may exclude those with current driven/compulsive exercise. PPV, Sensitivity, Specificity, and overall accuracy for current maldaptive exercise (#8) predicting current CET and EDEQ-assessed exercise will be high, supporting this single-item assessment of current maladaptive exercise on the ED100k.

[Figure 3](#fig-npv-usa) demonstrates confusion matrix components for ED100k scoring approaches and current compulsive/driven exercise endorsement assessed by 1. meeting CET clinical cutoff and 2. endorsement of EDEQ (any and at least weekly) driven exercise in the past 28 days. As hypothesized, approaches #1, 2, and 8 had a high NPV: those who did not endorse any history of, rare history of, or no current maladaptive exercise were unlikely to endorse current compulsive or driven exercise on the CET and EDEQ. NPVs for both CET clinical cutoff and weekly or more EDEQ driven exercise (4x or more over the past 28 days) were > 0.9. NPVs were slightly lower for reports of any EDEQ driven exercise over the past 28 days (~ 0.85), indicating that some individuals who endorse no history of compulsive exercise may engage in this behavior at relatively low frequency.

*Accuracy* and *positive predictive value* of #1, #2, #6, and #7 in relation to current measures of driven/compulsive exercise were all moderate, and specificity was low, indicating that many individuals who reported *history* of maladaptive exercise – via various operationalizations - on the ED100k were not engaging in compulsive/driven at the time of assessment. In contrast, xxx

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| Figure 3: Confusion matrix components of compulsive and maladaptive history vs. current CET and EDEQ exercise |

## Comparisons of continuous values of current exercise measures (external validation) across those with no history of maladaptive exericse,istory of, but not current, maladaptive exercise (Endorsing #2 but not #8), and those with current maladaptive exercise (#8) on the ED100k

H2b: Comparing across groups who report no history of maladaptive exercise, history of, but not current, maladaptive exercise (Endorsing #2 but not #8), and those with current maladaptive exercise (#8) on the ED100k, those who report ED100k current maladaptive exercise will report highest CET scores (total, and all subscales except for exercise enjoyment) and more driven exercise days in the past 28 on the EDEQ. Those reporting history of, but not current, maladaptive exercise will report intermediate CET scores and EDEQ exercise days – higher than those reporting no history of maladaptive exercise on the ED100k but lower than those reporting current maladaptive exercise.

Overall, 15.83% of the sample reported No history of maladaptive exercise, 44.01% reported a history of maladaptive exercise that was not current, and 40.17% reported current maladaptive exercise.

Boxplots with median standardized scores on all CET subscales along with CET total score is presented in [Figure 4](#fig-CETsubs-USA). To formally test the hypothesis that those with reporting ED100k current maladaptive exercise would also report the highest scores on the CET, we completed a series of ANOVAs comparing those with reporting no maladaptive exercise, history of maladaptive exercise only (Meeting Scoring Approach #2 but not #8), and current maladaptive exercise (Meeting Approach #8) on current CET scores. [Table 3](#tbl-CETANOVA) reports ANOVA output for each CET subscale, comparing across the three groups of individuals who report no maladaptive exercise, maladaptive exercise history but not current maladaptive exercise (#2 but NOT #8), and both history and current maladaptive exercise (#8) on the ED100k. All omnibus tests reach significance.

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| Figure 4: Median standardized CET subscale scores across those reporting no compulsive exercise, compulsive exercise history (not current), and current compulsive exercise on the ED100k |

Table 3: Omnibus ANOVA results comparing groups with current, history only, and no history of compulsive exercise on the ED100k on CET subscales

| Model | term | df | sumsq | meansq | statistic | p.value |
| --- | --- | --- | --- | --- | --- | --- |
| Enjoyment | ED100k History/Current Compulsive Exercise | 2 | 1143.95 | 571.98 | 327.21 | 1.550e-133 |
| Enjoyment | Residual | 4570 | 7988.46 | 1.75 | NA | NA |
| Mood Improve | ED100k History/Current Compulsive Exercise | 2 | 1328.57 | 664.29 | 479.63 | 5.767e-190 |
| Mood Improve | Residual | 4612 | 6387.64 | 1.39 | NA | NA |
| Avoidance | ED100k History/Current Compulsive Exercise | 2 | 3793.80 | 1896.90 | 1427.87 | 0.000e+00 |
| Avoidance | Residual | 4594 | 6103.03 | 1.33 | NA | NA |
| Rigidity | ED100k History/Current Compulsive Exercise | 2 | 2854.95 | 1427.48 | 927.38 | 0.000e+00 |
| Rigidity | Residual | 4565 | 7026.69 | 1.54 | NA | NA |
| Wt Control | ED100k History/Current Compulsive Exercise | 2 | 1858.56 | 929.28 | 717.69 | 4.113e-272 |
| Wt Control | Residual | 4615 | 5975.63 | 1.29 | NA | NA |
| Total | ED100k History/Current Compulsive Exercise | 2 | 17554.96 | 8777.48 | 180.19 | 4.283e-77 |
| Total | Residual | 7232 | 352287.57 | 48.71 | NA | NA |

[Table 4](#tbl-CETcontrasts) presents specific contrasts between each group, using a Tukey’s HSD approach with an adjusted alpha to compute confidence intervals of 0.0028 - accounting for 18 contrasts. All contrasts reach significance (confidence intervals of differences not overlapping ‘0’). Cohen’s D effects suggest a pattern of moderate effect size when comparing those with no history of maladaptive exercise to those with a history, but not current, maladaptive exercise and when comparing those with history vs. current maladaptive exercise. Comparison of those with no history of maladaptive exercise vs. current maladaptive exercise (#8) consistently demonstrated large effects. For all subscales, except for the (lack of) enjoyment subscale, effects indicated that those with current maladaptive exercise scored highest, while those with no history of maladaptive exercise scored the highest on the lack of exercise enjoyment subscale.

Table 4: Contrasts for each of the five CET subscales and the CET Total across those with and without history and current compulsive exercise as reported on the ED100k

| Variable | Contrast | Difference | CohensD |
| --- | --- | --- | --- |
| Enjoy | No vs Hx of Exercise | -0.78 ( -0.986, -0.574 ) | 0.553 |
| Enjoy | No vs. Current Exercise | -1.444 ( -1.653, -1.235 ) | 1.169 |
| Enjoy | Hx vs. Current Exercise | -0.664 ( -0.817, -0.511 ) | 0.506 |
| Mood Improve | No vs Hx of Exercise | 0.818 ( 0.635, 1.001 ) | -0.650 |
| Mood Improve | No vs. Current Exercise | 1.539 ( 1.354, 1.724 ) | -1.342 |
| Mood Improve | Hx vs. Current Exercise | 0.722 ( 0.586, 0.858 ) | -0.635 |
| Rigidity | No vs Hx of Exercise | 0.73 ( 0.536, 0.924 ) | -0.566 |
| Rigidity | No vs. Current Exercise | 2.07 ( 1.873, 2.267 ) | -1.742 |
| Rigidity | Hx vs. Current Exercise | 1.34 ( 1.197, 1.483 ) | -1.081 |
| Wt Control | No vs Hx of Exercise | 0.698 ( 0.521, 0.875 ) | -0.565 |
| Wt Control | No vs. Current Exercise | 1.714 ( 1.535, 1.893 ) | -1.674 |
| Wt Control | Hx vs. Current Exercise | 1.016 ( 0.886, 1.146 ) | -0.893 |
| Avoidance | No vs Hx of Exercise | 0.717 ( 0.537, 0.897 ) | -0.653 |
| Avoidance | No vs. Current Exercise | 2.313 ( 2.131, 2.495 ) | -2.010 |
| Avoidance | Hx vs. Current Exercise | 1.597 ( 1.464, 1.73 ) | -1.340 |
| Total | No vs Hx of Exercise | 1.479 ( 0.618, 2.34 ) | -0.241 |
| Total | No vs. Current Exercise | 4.094 ( 3.223, 4.965 ) | -0.552 |
| Total | Hx vs. Current Exercise | 2.615 ( 1.974, 3.256 ) | -0.361 |

The proportion of individuals meeting the clinical cutoff for current compulsive exercise on the CET varied as expected by endorsement of historical and current endorsement of maladaptive exercise on the ED100k. Only 5.76% of individuals who reported no history of maladaptive exercise met current CET clinical cutoff, while 18.78% of those reporting history, but not current maladaptive exercise (#2 but not #8) met clinical cutoff on the CET, and 62.76% of individuals meeting current maladaptive exercise (#8) on the ED100k met clinical cutoff for maladaptive exercise on the CET. Using a multinomial logistic regression approach with ‘No Maladaptive Exercise History’ on the ED100k coded as the reference category, those reporting maladaptive exercise history, but not current maladaptive exercise had an odds ratio of 3.78 and those reporting current maladaptive exercise had an odds ratio of 27.57, indicating significant convergent validity of reports of current maladaptive exercise on the ED100k and meeting clinical cutoff on the 24-item CET.

Regarding the number of days in the past 28 that participants reported engaging in driven exercise on the EDEQ, outcomes were zero-inflated in the ‘No History of Maladaptive Exercise’ and ‘History but No Current Maladaptive Exercise’ groups (see [Figure 5](#fig-EDEQplot-USA)).

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| Figure 5: ED100k Compulsive Exercise vs. EDEQ Exercise Frequency |

A zero-inflated Poisson regression model compared those with “History, but Not Current’ and those with ‘Current Maladaptive Exercise’ to the ‘No History of Maladaptive Exercise’ (reference) group on number of days with driven exercise in the past month. Results are presented in [Table 5](#tbl-EDEQZin) (including odds ratios (ORs) for the zero portion of the model and incident risk ratios (IRRs) for the count portion). Results indicate that those who report current maladaptive exercise on the ED100k are less likely to have zero values for EDEQ-assessed exercise in the past 28 days, and report higher counts of exercise days when they do exercise. Those reporting history of, but not current, maladaptive exercise on the ED100k are similarly less likely to report zero days of driven exercise on the EDEQ as compared to those who report no history of maladaptive exercise, though the count portion of the model indicates that those reporting history, but not current, maladaptive exercise are reporting low numbers of exercise days when it occurs, lower than those who report no history of maladaptive exercise.

Table 5: Zero-inflated Model Coefficients for ED100k Compulsive Exercise Predicting EDEQ Driven Exercise Days (past 28 days)

| Term | Model Part | Estimate | Std. Error | IRR | OR | z value | Pr(>|z|) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| (Intercept) | Count | 2.054 | 0.029 | 7.798 | NA | 70.380 | 0.00e+00 |
| History vs. No History | Count | -0.255 | 0.033 | 0.775 | NA | -7.704 | 1.32e-14 |
| Current vs. No History | Count | 0.613 | 0.030 | 1.846 | NA | 20.600 | 2.72e-94 |
| (Intercept) | Zero | 1.694 | 0.089 | NA | 5.441 | 19.131 | 1.39e-81 |
| History vs. No History | Zero | -0.644 | 0.099 | NA | 0.525 | -6.518 | 7.11e-11 |
| Current vs. No History | Zero | -3.249 | 0.103 | NA | 0.039 | -31.461 | 2.98e-217 |

## OCD Symptoms and Perfectionism

In addition to convergent validity across current exercise measures, we also examined both convergent and discriminant validity by examining ED100k scoring approaches on subscales of the Frost MPS indexing maladaptive perfectionism along with subscale and total scores for the OCI-R.

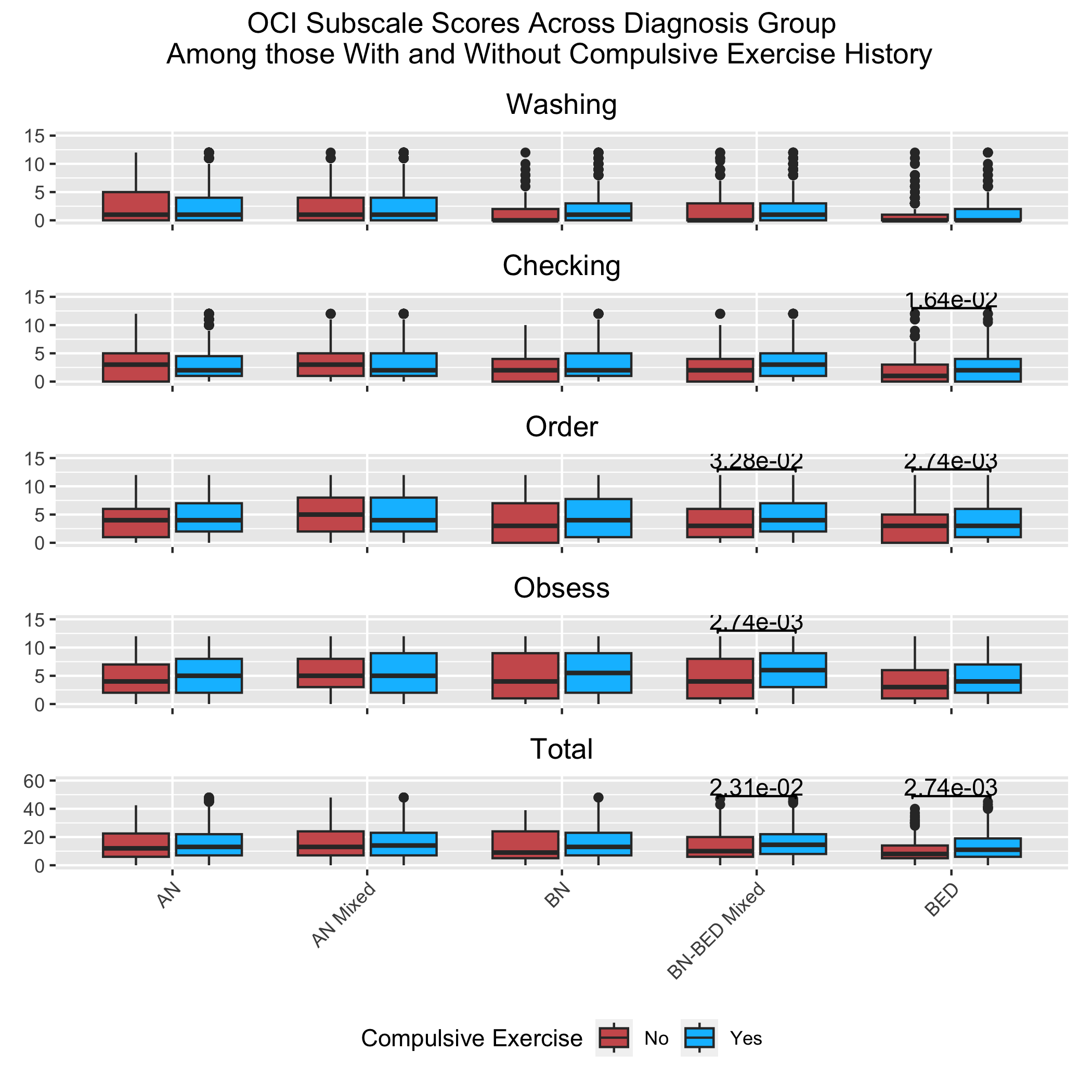
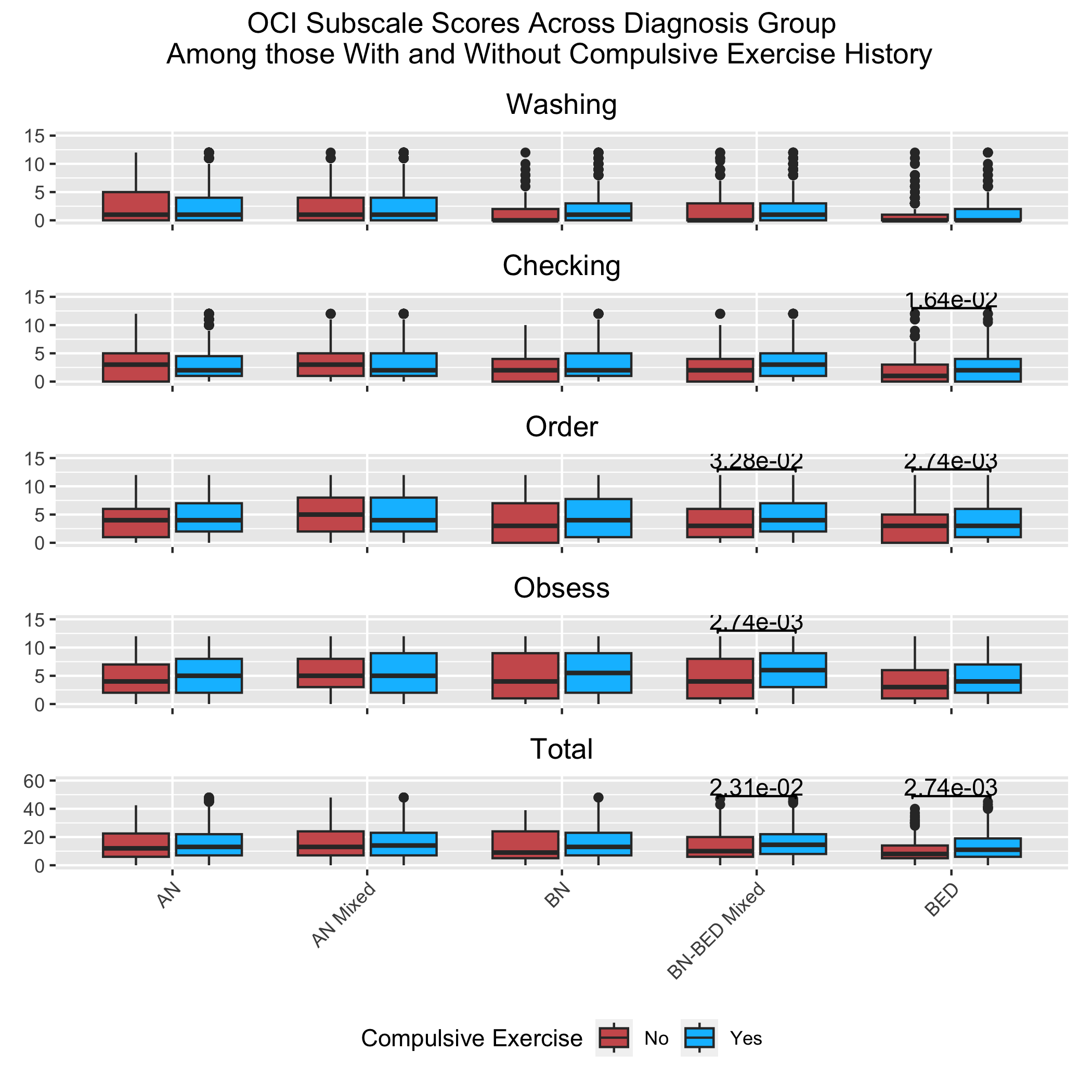
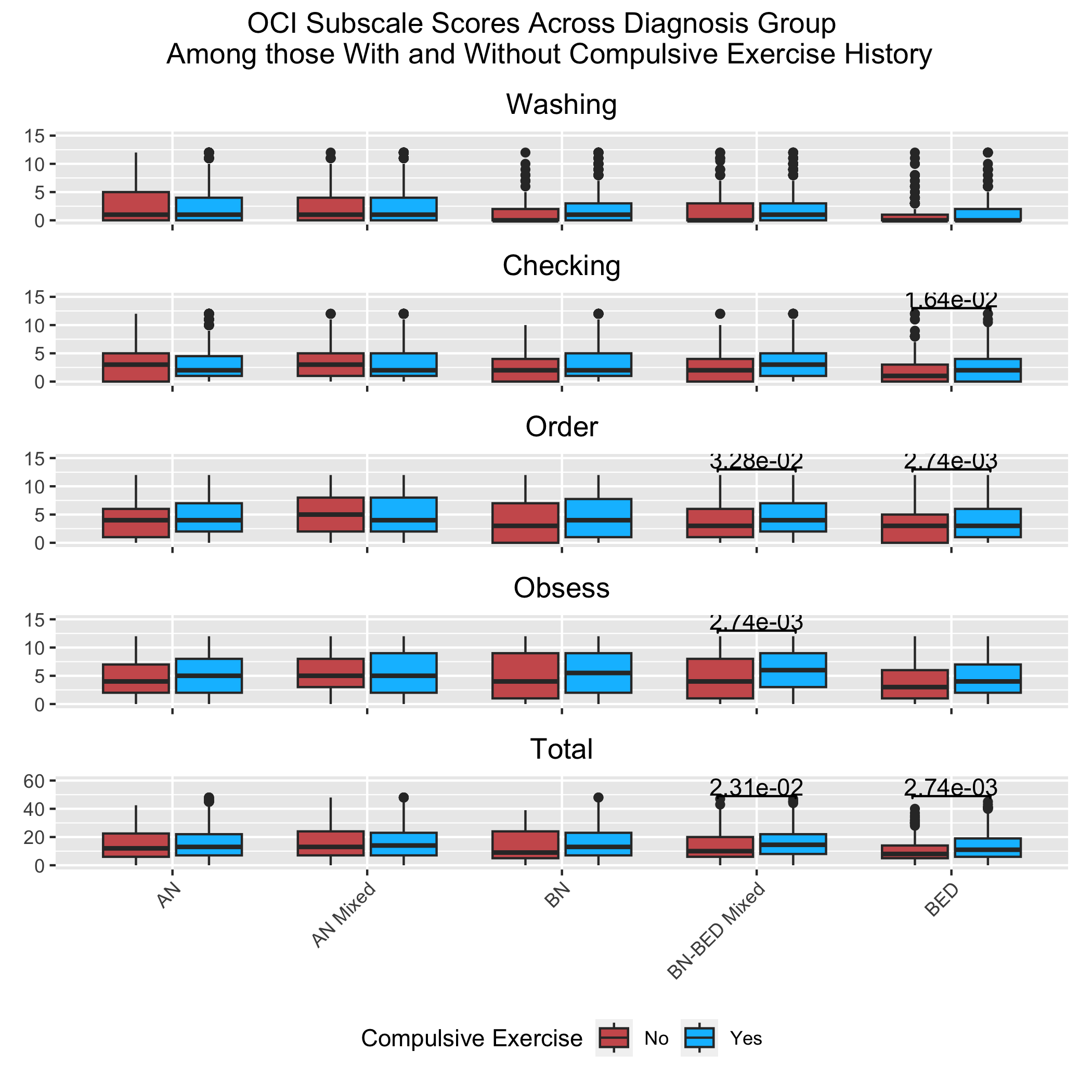
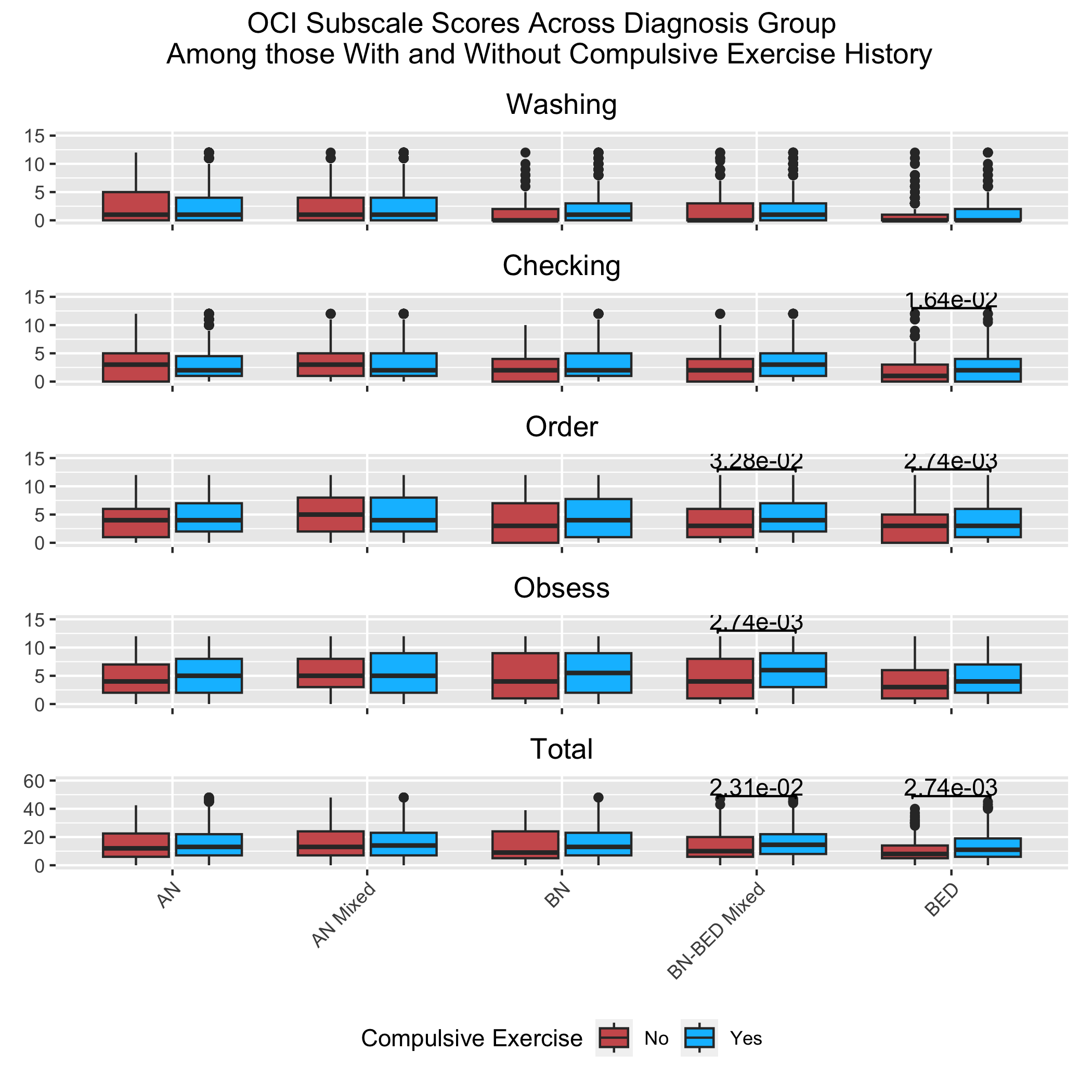
H2c: Within diagnostic groups - those endorsing scoring approaches #1, #2, #6, and #8 will report higher perfectionism and OCD symptoms. Those endorsing compenstory exercise (#7) will not report higher perfectionism or OCD symptoms than those who do not *t-tests within diagnostic groups comparing frost MPS and OCI-R/OCI-12 subscale scores across those with vs. without history of maladaptive exercise, expected p < 0.05 adjusted for multiple comparisons across subscales. We also include calculation of Cohen’s d effect sizes.*

Graphs depicting means and standard deviations for OCI total and subscale scores within diagnostic groups are presented in [Figure 6](#fig-OCI-USA). A table showing t-tests and Cohen’s D effect sizes for comparisons of subscale and total OCI scores within diagnostic groups is presented in Supplemental [Table 6](#tbl-oci-USA). Using FDR-adjusted (Benjamini-Hochberg) p-values across all 25 comparisons, OCI subscale and total scores did not significantly differ based on compulsive exercise history for those with AN, AN-Mixed, or BN diagnoses; however, those who reported compulsive exercise and a diagnosis of BN-BED mixed or BED only did have higher OCI scores (order, obsession and total for BED-BN mixed; checking, order, and total for BED) than those with similar diagnoses who id not report a history of compulsive exercise. Effect sizes were small (Range = 0.026-0.348; Median = 0.157).

Table 6: t-test output comparing those with and without compulsive exercise on OCI subscales and total scores within diagnostic groups

| Mean Diff | t | Case Status | variable | Cohens D | p | FDR p val |
| --- | --- | --- | --- | --- | --- | --- |
| 0.274 | 1.272 | AN | Washing | 0.091 | 2.05e-01 | 3.20e-01 |
| 0.154 | 0.740 | AN | Checking | 0.053 | 4.60e-01 | 5.23e-01 |
| -0.450 | -2.021 | AN | Order | 0.137 | 4.42e-02 | 1.11e-01 |
| -0.572 | -2.385 | AN | Obsess | 0.165 | 1.78e-02 | 5.81e-02 |
| -0.625 | -0.879 | AN | Total | 0.062 | 3.80e-01 | 5.23e-01 |
| -0.100 | -0.300 | AN Mixed | Washing | 0.031 | 7.65e-01 | 7.97e-01 |
| 0.258 | 0.793 | AN Mixed | Checking | 0.082 | 4.29e-01 | 5.23e-01 |
| 0.285 | 0.760 | AN Mixed | Order | 0.078 | 4.49e-01 | 5.23e-01 |
| -0.099 | -0.257 | AN Mixed | Obsess | 0.026 | 7.97e-01 | 7.97e-01 |
| 0.370 | 0.320 | AN Mixed | Total | 0.033 | 7.49e-01 | 7.97e-01 |
| -0.457 | -1.327 | BN | Washing | 0.157 | 1.87e-01 | 3.12e-01 |
| -0.581 | -1.733 | BN | Checking | 0.199 | 8.60e-02 | 1.79e-01 |
| -0.398 | -0.838 | BN | Order | 0.103 | 4.04e-01 | 5.23e-01 |
| -0.692 | -1.379 | BN | Obsess | 0.173 | 1.71e-01 | 3.05e-01 |
| -2.213 | -1.617 | BN | Total | 0.199 | 1.09e-01 | 2.10e-01 |
| -0.232 | -0.873 | BN-BED Mixed | Washing | 0.078 | 3.83e-01 | 5.23e-01 |
| -0.461 | -1.787 | BN-BED Mixed | Checking | 0.156 | 7.51e-02 | 1.71e-01 |
| -0.852 | -2.678 | BN-BED Mixed | Order | 0.238 | 7.88e-03 | 3.28e-02 |
| -1.184 | -3.638 | BN-BED Mixed | Obsess | 0.320 | 3.29e-04 | 2.74e-03 |
| -2.691 | -2.857 | BN-BED Mixed | Total | 0.256 | 4.62e-03 | 2.31e-02 |
| -0.521 | -2.251 | BED | Washing | 0.210 | 2.49e-02 | 6.92e-02 |
| -0.742 | -3.025 | BED | Checking | 0.280 | 2.63e-03 | 1.64e-02 |
| -1.162 | -3.739 | BED | Order | 0.348 | 2.10e-04 | 2.74e-03 |
| -0.767 | -2.362 | BED | Obsess | 0.219 | 1.86e-02 | 5.81e-02 |
| -3.162 | -3.680 | BED | Total | 0.343 | 2.63e-04 | 2.74e-03 |

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| Figure 6: OCI Means across diagnosis groups and ED100k exercise scoring criteria #1 |

Graphs depicting means and standard deviations for MPS total and subscale scores within diagnostic groups are presented in [Figure 7](#fig-MPS-USA). A table showing t-tests and Cohen’s D effect sizes for comparisons of MPS subscale scores within diagnostic groups is presented in Supplemental [Table 7](#tbl-MPS-USA). Using FDR-adjusted (Benjamini-Hochberg) p-values across all 15 comparisons, effect sizes showed significantly higher personal standards subsscales scores in all diagnostic groups for those who reported a history of compulsive exercise. Those with AN, BN-BED Mixed, and BED who reported a history of compulsive exercise had higher levels of concern over mistakes and doubts about action as compared to those with similar diagnoses who did not report a history of compulsive exercise. Cohen’s D effect sizes ranged from small-to-moderate (Range = 0.068-0.747; Median = 0.287).

Table 7: t-test output comparing those with and without compulsive exercise on MPS subscales and within diagnostic groups

| Mean Diff | t | Case Status | variable | Cohens D | p | FDR p val |
| --- | --- | --- | --- | --- | --- | --- |
| 2.393 | 9.595 | AN | Personal Standards | 0.747 | 1.40e-18 | 2.10e-17 |
| 1.737 | 6.212 | AN | Concern Over Mistakes | 0.474 | 2.34e-09 | 1.76e-08 |
| 1.012 | 3.688 | AN | Doubts About Actions | 0.271 | 2.78e-04 | 1.04e-03 |
| 1.012 | 2.460 | AN Mixed | Personal Standards | 0.304 | 1.58e-02 | 2.63e-02 |
| 0.425 | 0.871 | AN Mixed | Concern Over Mistakes | 0.107 | 3.86e-01 | 4.14e-01 |
| -0.276 | -0.579 | AN Mixed | Doubts About Actions | 0.068 | 5.64e-01 | 5.64e-01 |
| 1.055 | 2.400 | BN | Personal Standards | 0.324 | 1.87e-02 | 2.70e-02 |
| 0.731 | 1.339 | BN | Concern Over Mistakes | 0.185 | 1.84e-01 | 2.30e-01 |
| 0.704 | 1.284 | BN | Doubts About Actions | 0.174 | 2.03e-01 | 2.34e-01 |
| 1.179 | 3.394 | BN-BED Mixed | Personal Standards | 0.331 | 8.20e-04 | 2.46e-03 |
| 1.190 | 3.128 | BN-BED Mixed | Concern Over Mistakes | 0.300 | 1.99e-03 | 4.98e-03 |
| 1.079 | 2.704 | BN-BED Mixed | Doubts About Actions | 0.257 | 7.36e-03 | 1.38e-02 |
| 1.687 | 4.857 | BED | Personal Standards | 0.478 | 1.70e-06 | 8.50e-06 |
| 1.148 | 2.902 | BED | Concern Over Mistakes | 0.287 | 3.91e-03 | 8.38e-03 |
| 0.935 | 2.339 | BED | Doubts About Actions | 0.232 | 1.98e-02 | 2.70e-02 |

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| Figure 7: MPS subscale means across diagnosis groups and history of compulsive exericse |

# Aim 3. Demonstrate Prevalence of Maladaptive (Broad), Compulsive, Addictive, Excessive, and Compensatory Exercise across Diagnostic Groups

H3a. Maladaptive exercise, compulsive exercise, and exercise addiction will be a common symptom across diagnoses. We expect that these constructs will be more common in AN and BN than BED. *Rates of maladaptive exercise, compulsive exercise, excessive exercise, and exercise addiction will all be > 50% in AN and BN presentations; > 20% in BED. Contrasts between diagnostic groups will show higher rates of all constructs in AN and AN Mixed groups compared to BN only, BN-BED, and BED only groups*

H3b. Compensatory exercise will be more common among those with AN mixed and BN as compared to AN only . *AN mixed, BN, and BN-BED mixed groups will report higher levels of compensatory exercise than the AN only group. BED only will report similar levels of compensatory exercise to AN only*

Among individuals in the US EDGI data, 41.64% of the sample reported AN as their only diagnosis, 22.44% of the sample reported AN plus another diagnosis (AN mixed),12.37% reported a diagnosis of BN only, 9.11% reported a diagnosis of BED only (the smallest cell size: 661), and 14.44% reported both a BN and BED diagnosis.

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| Figure 8: Percentage within each diganostic group reporting differing exercise constructs |

Rates of addictive, compensatory, compulsive, excessive, and regular compulsive exercise across diagnostic groups are presented in [Figure 8](#fig-dxgroups-USA). History of addictive, regular compuslive, and excessive exercise were all highest in an absolute sense among groups reporting history of AN. History of Compulsive Exercise was reported most frequently in the AN, AN-Mixed Diagnosis, and BN groups, around 60% in each of these diagnostic groups reporting history of regular engagment of compulsive exericse, and the majority reporting at least some history of this behavior. Output from contrasts between all diagnostic groups are presented in Supplemental [Table 9](#tbl-dxcontrasts). Bonferroni adjusted p-values are reported accounting for 10 contrasts within each constructs Overall, groups differed significantly across all constructs, with the AN group reporting less compensatory exercise, but higher levels of all other exercise relative to BN and BED groups. The AN-Mixed group reported similar levels of all constructs to AN, with the exception of compensatory exercise, in which the AN Mixed group reported greater likelihood of to engagin in compensatory exercise. The BN group was more likely than BED and BN-BED Mixed groups to report all constructs, and the BN-BED group was more likely to report all constructs relative to the BED group.

Table 8: Item-level descriptives for ED100k Exercise Items

| Variable | Response | Freq | Percent |
| --- | --- | --- | --- |
| 1. Exercised excessively | No | 945 | 13.02 |
| 1. Exercised excessively | Sometimes | 1710 | 23.56 |
| 1. Exercised excessively | More Often | 4604 | 63.42 |
| 2. Compelled to Exercise | No | 1205 | 16.60 |
| 2. Compelled to Exercise | Yes | 6024 | 82.99 |
| 2. Compelled to Exercise | Missing | 30 | 0.41 |
| 3. Distressed when unable to exercise | No | 1485 | 20.46 |
| 3. Distressed when unable to exercise | Yes | 5675 | 78.18 |
| 3. Distressed when unable to exercise | Missing | 99 | 1.36 |
| 4. Interfering with Friendship | No | 2643 | 36.53 |
| 4. Interfering with Friendship | Yes | 4266 | 58.96 |
| 4. Interfering with Friendship | Missing | 326 | 4.51 |
| 5. Exercising when ill | No | 2496 | 34.50 |
| 5. Exercising when ill | Yes | 4481 | 61.94 |
| 5. Exercising when ill | Missing | 258 | 3.57 |
| 6. Modified Diet if unable to Exercise | No | 1599 | 22.10 |
| 6. Modified Diet if unable to Exercise | Yes | 5515 | 76.23 |
| 6. Modified Diet if unable to Exercise | Missing | 121 | 1.67 |
| 7. Exercise Duration | No compulsive exercise | 1145 | 15.83 |
| 7. Exercise Duration | Less than 1 month | 110 | 1.52 |
| 7. Exercise Duration | 1 to 2 months | 161 | 2.23 |
| 7. Exercise Duration | 3 to 5 months | 332 | 4.59 |
| 7. Exercise Duration | 6-12 months | 581 | 8.03 |
| 7. Exercise Duration | More than 1 year | 4689 | 64.81 |
| 7. Exercise Duration | Missing | 217 | 3.00 |
| 8. Exercise Frequency | No compulsive exercise | 1145 | 15.83 |
| 8. Exercise Frequency | Less than once a week | 176 | 2.43 |
| 8. Exercise Frequency | At least once a week | 359 | 4.96 |
| 8. Exercise Frequency | At least twice a week | 1100 | 15.20 |
| 8. Exercise Frequency | Every day/ nearly every day | 4320 | 59.71 |
| 8. Exercise Frequency | Missing | 135 | 1.87 |
| 9. Current Exercise | No History | 1145 | 15.83 |
| 9. Current Exercise | History, Not Current | 3184 | 44.01 |
| 9. Current Exercise | Current | 2906 | 40.17 |
| Q12. Compensatory Exercise | No | 3600 | 49.59 |
| Q12. Compensatory Exercise | Yes | 3659 | 50.41 |

Table 9: Odds Ratios for contrasts between all diagnostic groups within exercise construct

| DV | contrast | OR | se | p.value |
| --- | --- | --- | --- | --- |
| Compensatory | AN / AN Mixed | 0.057 | 0.005 | 6.68e-281 |
| Compensatory | AN / BED | 0.580 | 0.054 | 5.12e-08 |
| Compensatory | AN / BN | 0.079 | 0.007 | 1.36e-165 |
| Compensatory | AN / (BN-BED Mixed) | 0.146 | 0.011 | 1.44e-131 |
| Compensatory | AN Mixed / BED | 10.090 | 1.070 | 2.85e-104 |
| Compensatory | AN Mixed / BN | 1.378 | 0.145 | 2.28e-02 |
| Compensatory | AN Mixed / (BN-BED Mixed) | 2.535 | 0.237 | 2.32e-22 |
| Compensatory | BED / BN | 0.137 | 0.016 | 3.11e-65 |
| Compensatory | BED / (BN-BED Mixed) | 0.251 | 0.026 | 2.75e-38 |
| Compensatory | BN / (BN-BED Mixed) | 1.840 | 0.192 | 5.14e-08 |
| Compulsive | AN / AN Mixed | 0.914 | 0.097 | 1.00e+00 |
| Compulsive | AN / BED | 10.313 | 1.025 | 8.84e-121 |
| Compulsive | AN / BN | 1.445 | 0.167 | 1.42e-02 |
| Compulsive | AN / (BN-BED Mixed) | 2.749 | 0.264 | 5.75e-25 |
| Compulsive | AN Mixed / BED | 11.285 | 1.318 | 1.03e-94 |
| Compulsive | AN Mixed / BN | 1.582 | 0.207 | 4.51e-03 |
| Compulsive | AN Mixed / (BN-BED Mixed) | 3.008 | 0.342 | 3.76e-21 |
| Compulsive | BED / BN | 0.140 | 0.018 | 1.44e-54 |
| Compulsive | BED / (BN-BED Mixed) | 0.267 | 0.029 | 7.62e-34 |
| Compulsive | BN / (BN-BED Mixed) | 1.902 | 0.233 | 1.51e-06 |
| Addictive | AN / AN Mixed | 0.958 | 0.065 | 1.00e+00 |
| Addictive | AN / BED | 11.683 | 1.308 | 7.33e-106 |
| Addictive | AN / BN | 1.541 | 0.122 | 4.96e-07 |
| Addictive | AN / (BN-BED Mixed) | 2.679 | 0.199 | 2.28e-39 |
| Addictive | AN Mixed / BED | 12.196 | 1.440 | 1.39e-98 |
| Addictive | AN Mixed / BN | 1.609 | 0.141 | 6.00e-07 |
| Addictive | AN Mixed / (BN-BED Mixed) | 2.797 | 0.232 | 3.23e-34 |
| Addictive | BED / BN | 0.132 | 0.016 | 4.25e-58 |
| Addictive | BED / (BN-BED Mixed) | 0.229 | 0.028 | 1.03e-32 |
| Addictive | BN / (BN-BED Mixed) | 1.738 | 0.161 | 2.33e-08 |
| Regular Compulsive | AN / AN Mixed | 1.004 | 0.069 | 1.00e+00 |
| Regular Compulsive | AN / BED | 10.936 | 1.162 | 3.65e-111 |
| Regular Compulsive | AN / BN | 1.608 | 0.129 | 2.91e-08 |
| Regular Compulsive | AN / (BN-BED Mixed) | 2.745 | 0.203 | 2.81e-41 |
| Regular Compulsive | AN Mixed / BED | 10.896 | 1.229 | 1.44e-98 |
| Regular Compulsive | AN Mixed / BN | 1.602 | 0.142 | 9.83e-07 |
| Regular Compulsive | AN Mixed / (BN-BED Mixed) | 2.735 | 0.227 | 1.02e-32 |
| Regular Compulsive | BED / BN | 0.147 | 0.018 | 1.47e-56 |
| Regular Compulsive | BED / (BN-BED Mixed) | 0.251 | 0.029 | 9.66e-32 |
| Regular Compulsive | BN / (BN-BED Mixed) | 1.707 | 0.158 | 7.63e-08 |
| Excessive | AN / AN Mixed | 0.871 | 0.060 | 4.44e-01 |
| Excessive | AN / BED | 6.734 | 0.686 | 3.53e-77 |
| Excessive | AN / BN | 1.589 | 0.126 | 6.05e-08 |
| Excessive | AN / (BN-BED Mixed) | 2.174 | 0.163 | 2.85e-24 |
| Excessive | AN Mixed / BED | 7.728 | 0.841 | 1.06e-77 |
| Excessive | AN Mixed / BN | 1.823 | 0.161 | 1.08e-10 |
| Excessive | AN Mixed / (BN-BED Mixed) | 2.495 | 0.210 | 1.45e-26 |
| Excessive | BED / BN | 0.236 | 0.027 | 1.85e-34 |
| Excessive | BED / (BN-BED Mixed) | 0.323 | 0.036 | 1.39e-22 |
| Excessive | BN / (BN-BED Mixed) | 1.368 | 0.128 | 7.79e-03 |
| Maladaptive | AN / AN Mixed | 0.798 | 0.088 | 4.12e-01 |
| Maladaptive | AN / BED | 10.088 | 1.001 | 5.91e-119 |
| Maladaptive | AN / BN | 1.401 | 0.164 | 3.85e-02 |
| Maladaptive | AN / (BN-BED Mixed) | 2.528 | 0.246 | 1.70e-20 |
| Maladaptive | AN Mixed / BED | 12.648 | 1.525 | 2.54e-97 |
| Maladaptive | AN Mixed / BN | 1.757 | 0.238 | 3.12e-04 |
| Maladaptive | AN Mixed / (BN-BED Mixed) | 3.170 | 0.377 | 3.34e-21 |
| Maladaptive | BED / BN | 0.139 | 0.018 | 2.77e-54 |
| Maladaptive | BED / (BN-BED Mixed) | 0.251 | 0.027 | 2.63e-36 |
| Maladaptive | BN / (BN-BED Mixed) | 1.804 | 0.225 | 2.17e-05 |

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| --- | --- | --- |
| **Variable name** | **Question** | **Response options** |
| exercise | Exercised excessively  (e.g. felt compelled to exercise, felt uneasy or distressed if unable to exercise) | 1=never; 2=a few times, but it never became a habit; 3=more often |
| ex\_compel | Have you ever felt compelled to exercise-like you had to do it-to control your body shape or weight? | 1=Yes | 0=No | -9=Don’t know |
| ex\_distress | Have you ever felt uneasy or distressed if unable to exercise? | 1=Yes | 0=No | -9=Don’t know |
| ex\_friend | Have there been times when you declined opportunities to be with friends in order to exercise? | 1=Yes | 0=No | -9=Don’t know |
| ex\_ill | Have you exercised despite an injury or illness that would have prevented others from exercising? | 1=Yes | 0=No | -9=Don’t know |
| ex\_diet | Have there been times you modified your diet/eating habits if you were unable to exercise for any reason? | 1=Yes | 0=No | -9=Don’t know |
| ex\_age | How old were you when you first exercised to control your weight and shape AND felt either compelled to exercise or distressed if unable to exercise? | integer, Min:0, Max: 120 |
| ex\_dur | For how long did you feel compelled to exercise or felt distressed if unable to exercise? | 1=Less than 1 month | 2=1 to 2 months | 3=3 to 5 months | 4=6-12 months | 5=More than 1 year | -9=Don’t know |
| ex\_freq | During these periods, how frequently did you exercise excessively in a week? | 1=Less than once a week | 2=At least once a week | 3=At least twice a week | 4=Every day/ nearly every day | -9=Don’t know |
| ex\_current | Do you currently exercise to control weight and shape AND feel compelled to exercise or distress if unable to exercise? | 1=Yes | 0=No |
| ex\_age\_last | How old were you when you stopped exercising to control your weight and shape AND felt either compelled to exercise or distressed if unable to exercise? | integer, Min:0, Max: 120 |
| Be\_icb\_5 | Have you ever used any of the following to compensate for episodes of binge eating or overeating? (Mark all that apply) (choice=Exercised excessively (e.g., felt compelled to exercise, felt uneasy or distressed if unable to exercise)) |  |
| Icb\_lowt\_5 | Exercised excessively (e.g., felt compelled to exercise, felt uneasy or distressed if unable to exercise) |  |