Subgroup analysis: habitual breakfast eaters versus breakfast skippers.

Methods

We calculated a secondary analysis comparing habitual breakfast eaters (Eaters) versus habitual breakfast skippers (Skippers), as defined by the authors of the published papers. If baseline habits were not reported, or if authors reported that the baseline habits of the participants were mixed, the study arms were excluded. The subgroup analysis was based on the same effect size estimates generated for the primary analysis. The same functions were used in R, except for modeling the outcome variable as a function of both assigned condition and baseline breakfast habits. This approach computes a formal analysis of differences between subgroups, and thus tests for the interaction between baseline breakfast habit and experimental breakfast assignment.

Each study arm was assumed to be independent, though we recognize there may be some greater similarity within studies that stratified by baseline habits (e.g., the Eater vs Skipper strata of Dhurhandar et al. may be more similar than participants across strata in other studies by virtue of being a part of the same study, even though each strata-by-assignment group included independent samples). The code for these analyses is now incorporated in the 'metaanalysis with subgroup.R' file in our Zenodo repository, which replaces the previous 'metaanalysis.R' file.

Results and Discussion

The Appendix Table summarizes the subgroup comparisons for the five outcomes for which there were enough effect sizes to calculate the subgroup test. Body weight had the greatest number of study arms, with 4 Eater effect sizes against 5 Skipper effect sizes. The fewest were 1 Eater effect size compared against 2 Skipper effect sizes for fat mass and lean mass. The other outcomes had no effect sizes in at least one of the subgroups.

Of the 5 outcomes, only BMI was statistically significant. The negative estimate of –0.36[-0.65,-0.07] BMI units indicates that individuals assigned to conditions consistent with their baseline habits had lower values than those assigned opposite of their habits. That is, Skippers had lower BMI when skipping breakfast and Eaters had lower BMI when eating breakfast, compared to Skippers eating and Eaters skipping. This is reflected by the subgroup summary gray diamonds in supplemental figure 2. Subgroup summary effect estimates were higher in the Skippers and lower in the Eaters.

We note several limitations. First, as depicted in the supplementary forest plots (Supplementary Figure 2 for BMI), there are few effect sizes available to estimate these comparisons. Second, multiple comparisons were not accounted for, thus inflating the potential for a type I error. Third, body weight was not statistically significant, yet is a component of BMI. This discrepancy may be explained by the nature of BMI being a ratio, but could also reflect the instability of the estimate when the fewer effect sizes were included (a total of 6 effect sizes included for BMI, while a total of 9 were included for body weight). These limitations reinforce that more research is needed to more reliably resolve these questions.

Figure Legends for Supplemental Forest Plots

The five outcomes for which the interaction between baseline breakfast habits and experimental breakfast assignment are presented in the supplemental forest plots: body weight, BMI, body fat percentage, fat mass, and lean mass. The point estimate is represented by a square, with the size of the square proportional to the weight of the estimate in the meta-analysis, with a 95% confidence interval. Positive values indicate that the outcome is higher when individuals were assigned to eat breakfast (e.g., a positive body weight effect indicates that individuals assigned to eat breakfast had a higher body weight change on average than those assigned to skip).

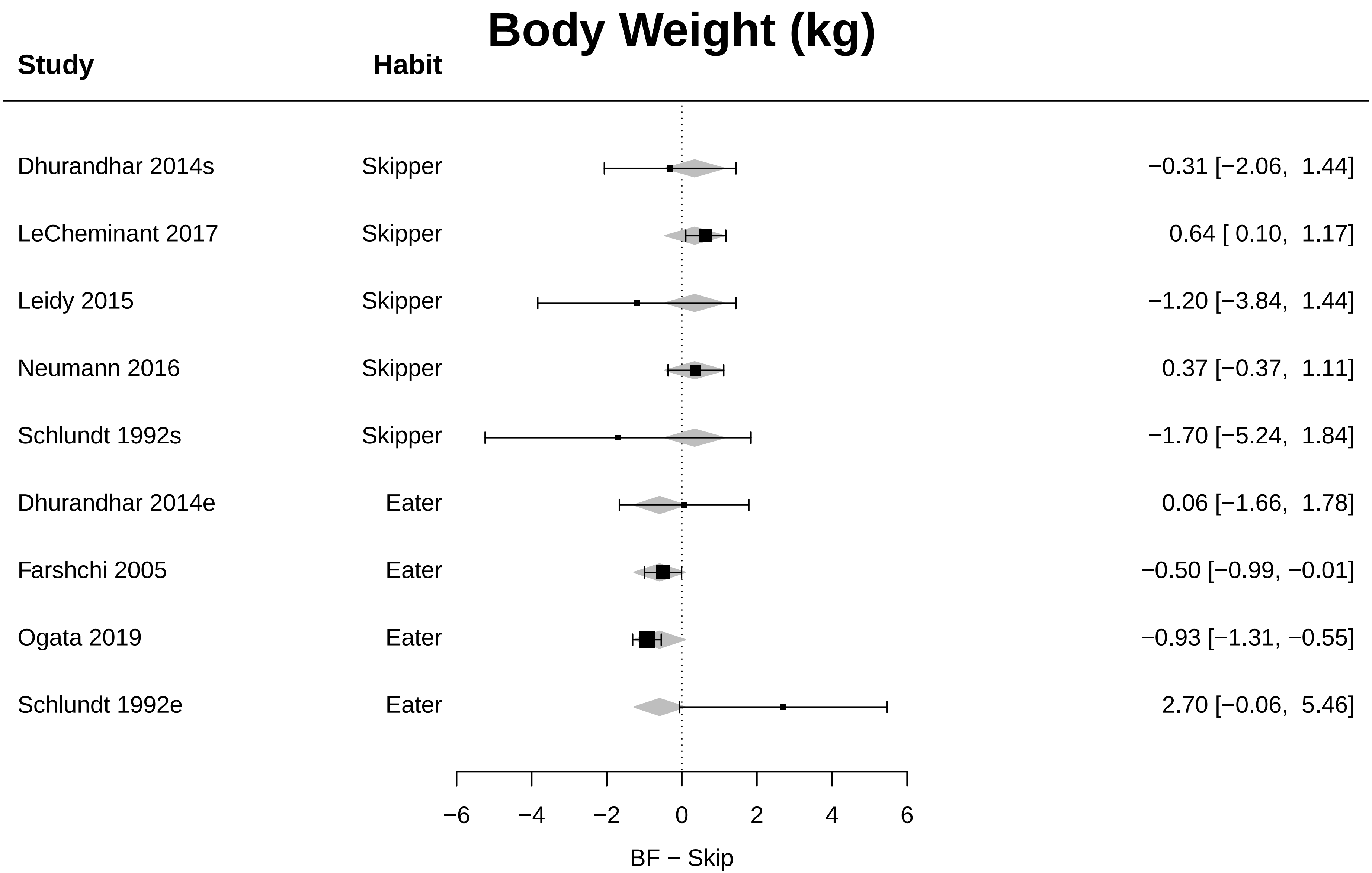
The gray diamonds represent the summary value for individuals with that baseline breakfast habit. There are only two subgroup estimates (gray diamonds) for each forest plot: the effects of eating versus skipping breakfast for baseline breakfast skippers, and the effects of eating versus skipping breakfast for baseline breakfast eaters. Gray diamonds are repeatedly plotted with the individual effect estimates within baseline habit for comparison.

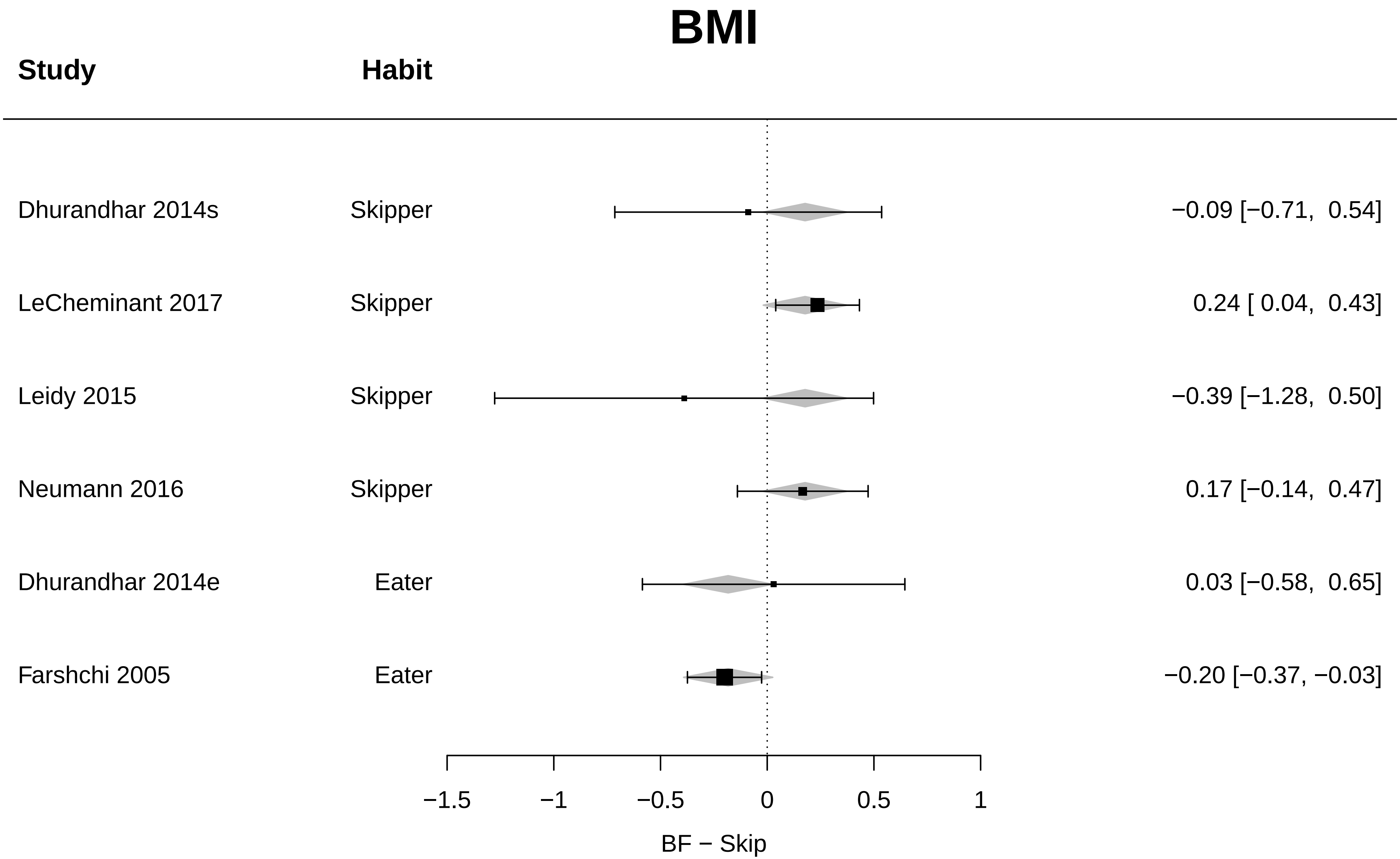
Appendix table: Subgroup analysis based on participant breakfast habits

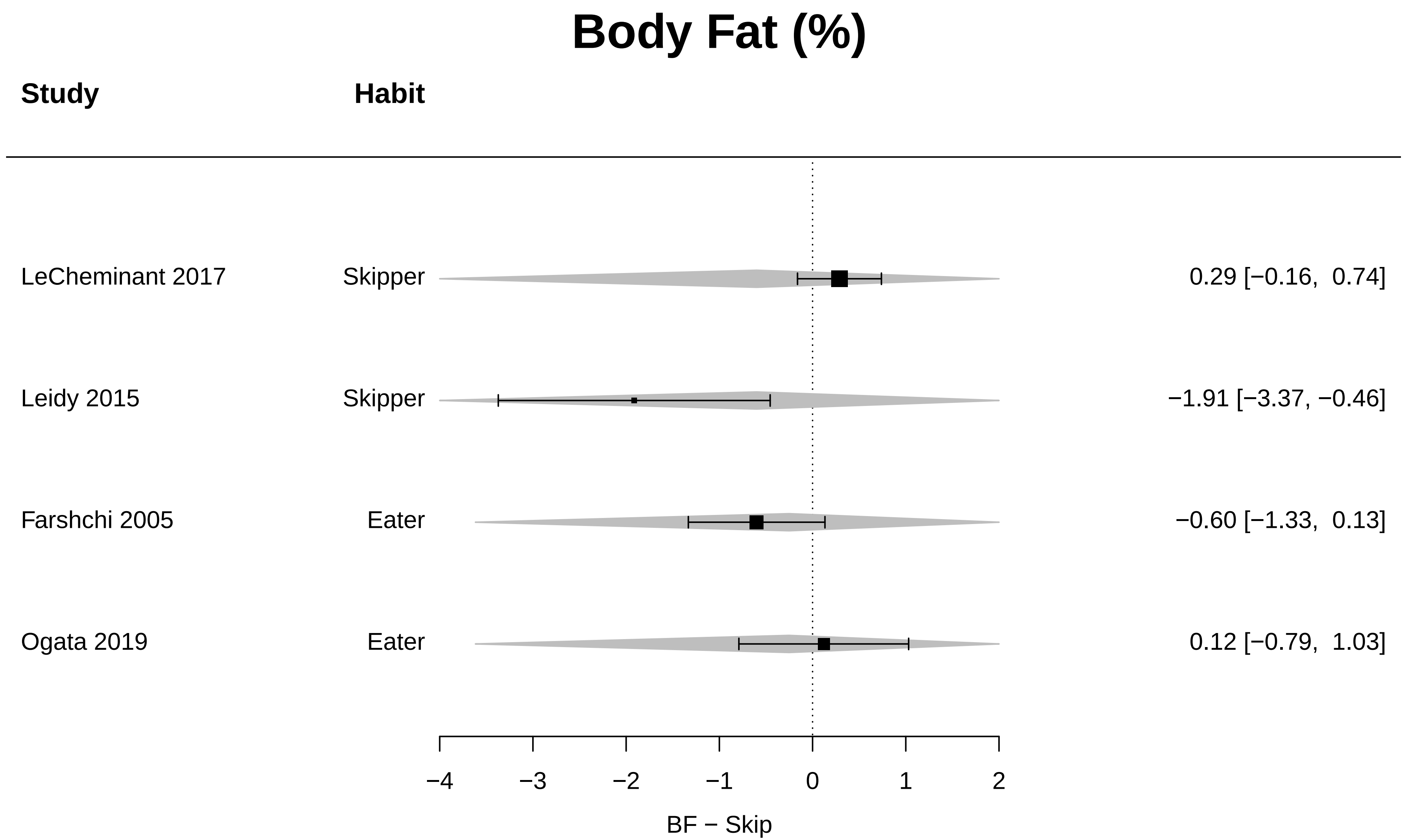
Outcome	k (Eaters)	k (Skippers)	Eaters vs Skippers [a]	LCI (95%)	UCI (95%)	I-squared (%)	Residual heterogeneity p-value
Body Weight (kg)	4	5	-0.9345	-1.9743	0.1053	26.29	0.0787
BMI[b]	2	4	-0.3606	-0.6472	-0.0740	0	0.5397
Body Fat (%)	2	2	0.3489	-4.4890	5.1869	81.66	0.0089
Fat Mass (g)	1	2	0.8055	-21.8774	23.4884	81.13	0.0213
Lean Mass (g)	1	2	0.4557	-2.7789	3.6903	0	0.4574

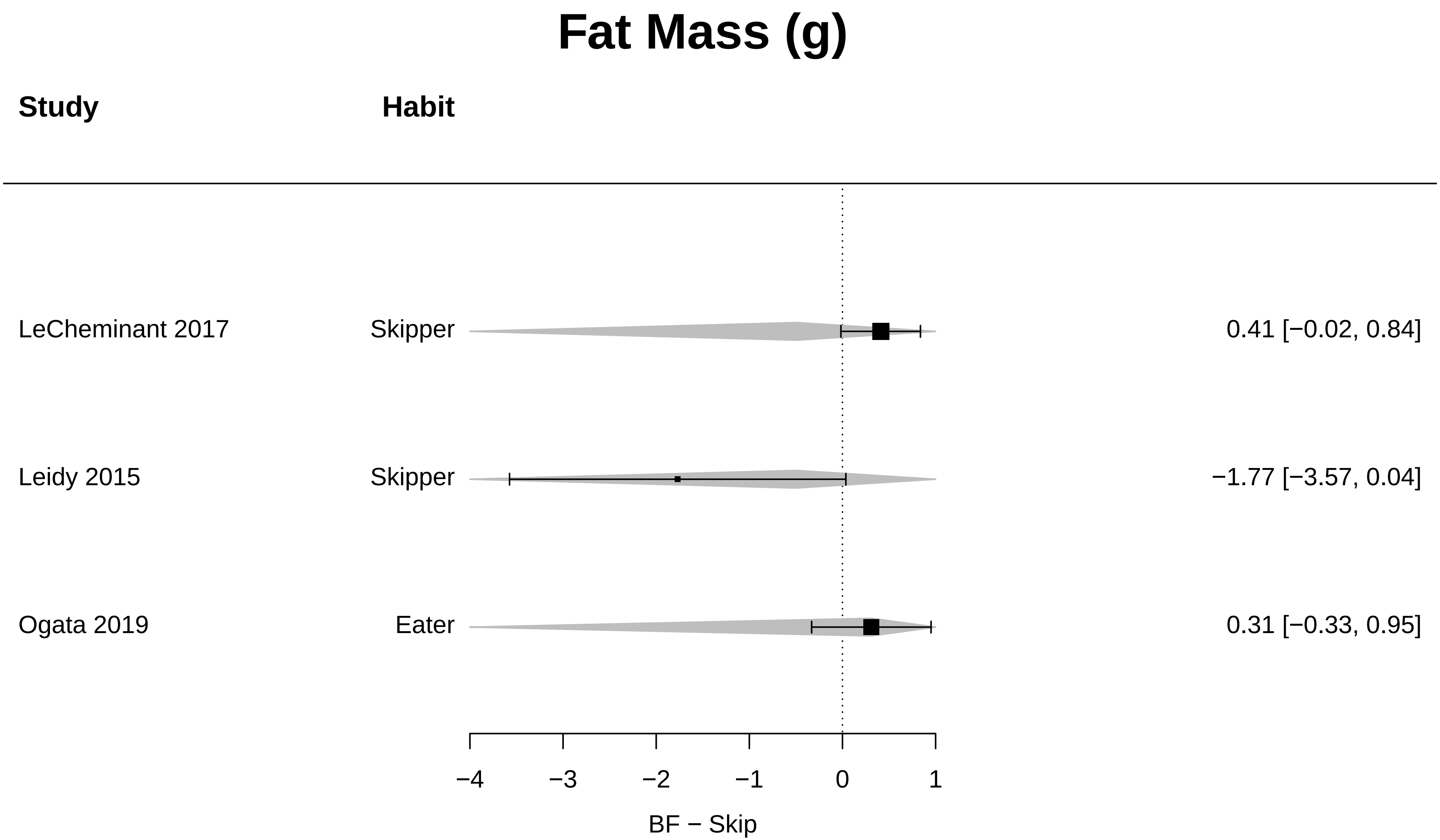
[a]This column represents the between-group point estimate, followed by the lower and upper confidence intervals (LCI and UCI, respectively). A positive value indicates that individuals assigned to their typical habits had lower outcome values compared to individuals assigned opposite of their habits.

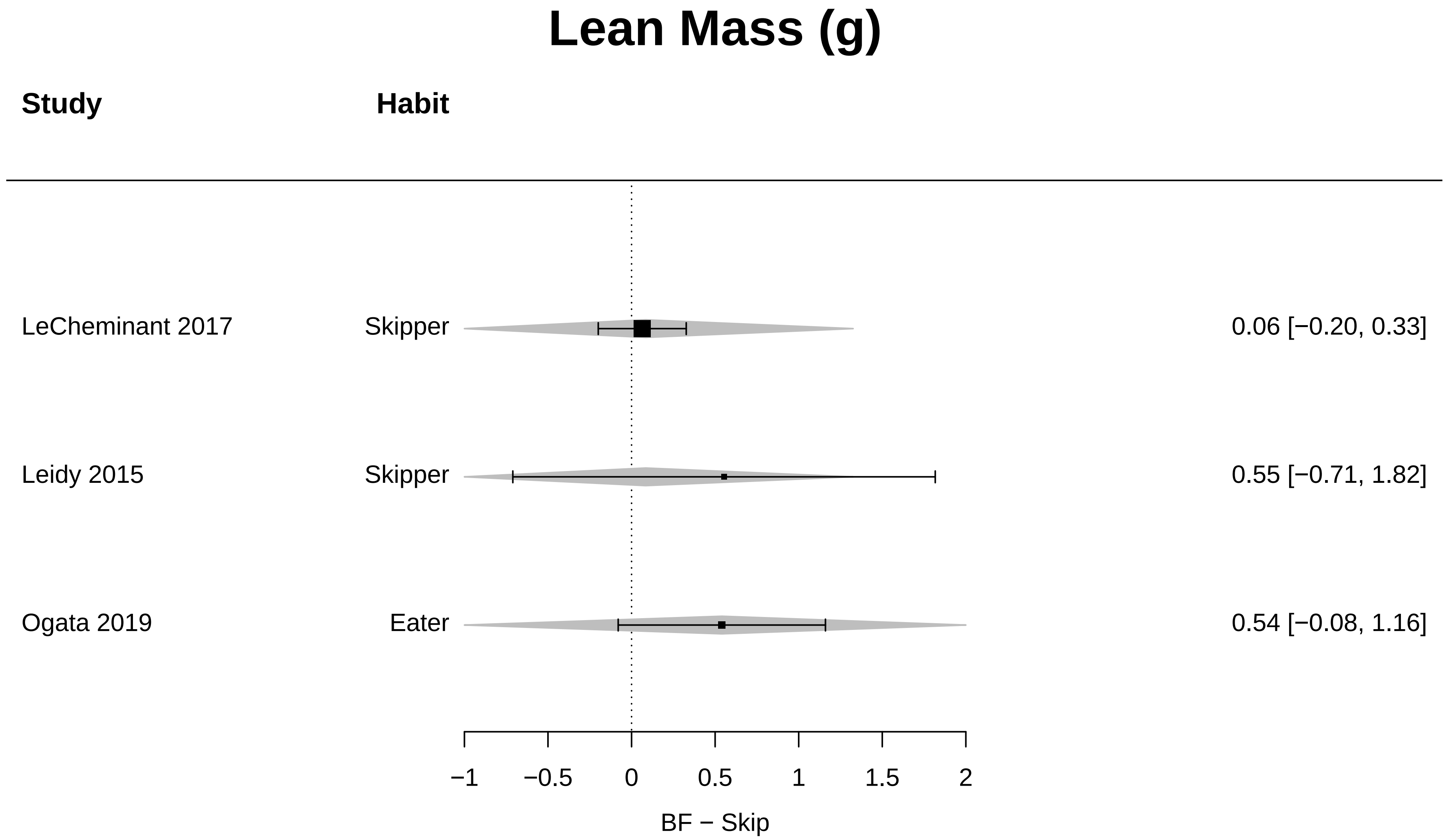
[b]BMI is statistically significant at the 0.05 alpha level, as indicated by the confidence interval excluding 0.


Body Weight (kg)
Study
Habit
Dhurandhar 2014s
Skipper
−0.31 [−2.06, 1.44]
LeCheminant 2017
Skipper
0.64 [0.10, 1.17]
Leidy 2015
Skipper
−1.20 [−3.84, 1.44]
Neumann 2016
Skipper
0.37 [−0.37, 1.11]
Schlundt 1992s
Skipper
−1.70 [−5.24, 1.84]
Dhurandhar 2014e
Eater
0.06 [−1.66, 1.78]
Farshchi 2005
Eater
−0.50 [−0.99, −0.01]
Ogata 2019
Eater
−0.93 [−1.31, −0.55]
Schlundt 1992e
Eater
2.70 [−0.06, 5.46]
−6
−4
−2
0
2
4
6
BF − Skip


BMI
Study
Habit
Dhurandhar 2014s Skipper −0.09 [−0.71, 0.54]
LeCheminant 2017 Skipper 0.24 [0.04, 0.43]
Leidy 2015 Skipper −0.39 [−1.28, 0.50]
Neumann 2016 Skipper 0.17 [−0.14, 0.47]
Dhurandhar 2014e Eater 0.03 [−0.58, 0.65]
Farshchi 2005 Eater −0.20 [−0.37, −0.03]
−1.5 −1 −0.5 0 0.5 1
BF − Skip


Body Fat (%)
Study
Habit
LeCheminant 2017
Skipper
0.29 [−0.16, 0.74]
Leidy 2015
Skipper
−1.91 [−3.37, −0.46]
Farshchi 2005
Eater
−0.60 [−1.33, 0.13]
Ogata 2019
Eater
0.12 [−0.79, 1.03]
−4
−3
−2
−1
0
1
2
BF − Skip


Fat Mass (g)
Study
Habit
LeCheminant 2017
Skipper
0.41 [−0.02, 0.84]
Leidy 2015
Skipper
−1.77 [−3.57, 0.04]
Ogata 2019
Eater
0.31 [−0.33, 0.95]
−4
−3
−2
−1
0
1
BF − Skip


Lean Mass (g)
Study
Habit
LeCheminant 2017
Skipper
0.06 [−0.20, 0.33]
Leidy 2015
Skipper
0.55 [−0.71, 1.82]
Ogata 2019
Eater
0.54 [−0.08, 1.16]
−1
−0.5
0
0.5
1
1.5
2
BF − Skip