Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.
Table 1. Associations of FEI With Semen Quality and Biochemistry Parameters of Seminal Plasma in Different Level of SOD Before and After Adjusting for Confounding Factors

|                | Low level of SOD |                | High level of SOD |                |
|----------------|------------------|----------------|-------------------|----------------|
|                | Crude            | Adjusted       | Crude             | Adjusted       |
|                | Effect estimate  | 95%CI           | P value           | Effect estimate| 95%CI           | P value           | Effect estimate  | 95%CI           | P value           |
|                | e(%)             | lower higher    |                   | e(%)           | lower Higher    |                   | e(%)             | lower Higher    |                   |
| TSM            | -0.99            | 1.00            | -0.97             | <0.001<sup>c</sup> | -0.99           | -0.95            | <0.001<sup>c</sup> | -0.94            | -0.99           | 0.35             | 0.076            | -0.97            | -0.99           | 0.56             | 0.066            |
| PSM            | -0.99            | 1.00            | -0.96             | <0.001<sup>c</sup> | -0.99           | -0.95            | <0.001<sup>c</sup> | -0.91            | -0.99           | 0.38             | 0.083            | -0.96            | -0.99           | 1.75             | 0.070             |
| VCL            | -0.05            | -0.09           | -0.01             | 0.009<sup>c</sup> | -0.05           | -0.09            | -0.01             | 0.015<sup>c</sup> | -0.02            | -0.06           | 0.00             | 0.147            | -0.02            | -0.06           | 0.00             | 0.103             |
| VSL            | -0.08            | -0.13           | -0.03             | 0.003<sup>c</sup> | -0.08           | -0.13            | -0.03             | 0.002<sup>c</sup> | -0.03            | -0.08           | 0.00             | 0.086            | -0.04            | -0.09           | 0.00             | 0.055             |
| VAP            | -0.08            | -0.13           | -0.03             | 0.002<sup>c</sup> | -0.08           | -0.13            | -0.03             | 0.002<sup>c</sup> | -0.04            | -0.08           | 0.00             | 0.066            | -0.05            | -0.09           | 0.07             | 0.069             |
| BCF            | 0.26             | -0.20           | 1.00              | 0.313           | 0.38           | -0.11           | 1.16              | 0.155           | 0.38           | -0.01           | 0.94             | 0.058            | 0.44            | -0.02           | 1.05             | 0.068             |
| NSM            | -0.93            | -0.99           | -0.50             | 0.009<sup>c</sup> | -0.91           | -0.98           | -0.38             | 0.016<sup>c</sup> | -0.97           | -0.99           | -0.79             | 0.001<sup>c</sup> | -0.97           | -0.99           | -0.80             | <0.001<sup>c</sup> |
| DFI            | 0.10             | 0.05           | 0.16              | <0.001<sup>c</sup> | 0.10           | 0.04           | 0.16              | <0.001<sup>c</sup> | 0.05           | -0.00           | 0.10             | 0.074            | 0.05            | -0.00           | 0.11             | 0.057             |
| NG             | -0.34            | -0.48           | -0.16             | 0.001<sup>c</sup> | -0.31           | -0.46           | -0.13             | 0.002<sup>c</sup> | 0.02           | -0.17           | 0.25             | 0.848            | 0.01            | -0.18           | 0.25             | 0.882             |
| Zinc           | -0.64            | -0.70           | -0.57             | <0.001<sup>c</sup> | -0.64           | -0.70           | -0.56             | <0.001<sup>c</sup> | -0.54           | -0.62           | -0.46             | <0.001<sup>c</sup> | -0.54           | -0.61           | -0.45             | <0.001<sup>c</sup> |

<sup>a</sup> Confounding factors used in the adjusting model contained age, BMI, income, smoking status, and alcohol consumption.

<sup>b</sup> Effect estimates represented their percentage changes in association with a unit increase in FEI.

Abbreviations: TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency; NG, Neutral glucosidase.

<sup>c</sup> P<0.05.
eTable 2. Associations of FEI With Semen Quality and Biochemistry Parameters of Seminal Plasma in Different Level of MDA Before and After Adjusting for Confounding Factors

|                | Low level of MDA |                   | High level of MDA |                   |
|----------------|-------------------|-------------------|-------------------|-------------------|
|                | Crude             | Adjusted          | Crude             | Adjusted          |
|                | Effect estimate e2(%) | 95%CI  | P value   | Effect estimate e2(%) | 95%CI  | P value   | Effect estimate e2(%) | 95%CI  | P value   |
|                | lower  | higher |  | lower  | higher |  |  | lower  | higher |  |  |
| TSM            | -0.84 | -0.99  | 2.39 | 0.235 | -0.85 | -0.99  | 1.97 | 0.205 | -0.99 | -0.99  | -0.97 | <0.001c | -0.99 | -0.99  | -0.97 | <0.001c |
| PSM            | -0.79 | -0.98  | 1.74 | 0.228 | -0.85 | -0.98  | 1.00 | 0.149 | -0.99 | -0.99  | -0.97 | <0.001c | -0.99 | -0.99  | -0.97 | <0.001c |
| VCL            | -0.01 | -0.05  | 0.02 | 0.354 | -0.02 | -0.05  | 0.01 | 0.247 | -0.05 | -0.08  | -0.02 | 0.002c | -0.04 | -0.08  | -0.01 | 0.003c |
| VSL            | -0.04 | -0.08  | 0.00 | 0.078 | -0.05 | -0.09  | 0.00 | 0.061 | -0.07 | -0.11  | -0.03 | <0.001c | -0.07 | -0.11  | -0.03 | <0.001c |
| VAP            | -0.04 | -0.08  | 0.00 | 0.073 | -0.05 | -0.09  | 0.00 | 0.053 | -0.08 | -0.11  | -0.04 | <0.001c | -0.07 | -0.11  | -0.03 | <0.001c |
| BCF            | 0.25  | -0.11  | 0.78 | 0.196 | 0.29  | -0.08  | 0.83 | 0.145 | 0.61  | 0.15   | 1.26  | 0.006c | 0.64  | 0.17   | 1.30  | 0.004c |
| NSM            | -0.70 | -0.95  | 0.92 | 0.198 | -0.76 | -0.96  | 0.64 | 0.144 | -0.98 | -0.99  | -0.92 | <0.001c | -0.97 | -0.99  | -0.91 | <0.001c |
| DFI            | 0.02  | -0.02  | 0.07 | 0.418 | 0.01  | -0.03  | 0.06 | 0.553 | 0.11  | 0.07   | 0.15  | <0.001c | 0.10  | 0.06   | 0.15  | <0.001c |
| NG             | -0.01 | -0.21  | 0.22 | 0.876 | -0.00 | -0.20  | 0.23 | 0.937 | -0.32 | -0.42  | -0.19 | <0.001c | -0.29 | -0.41  | -0.14 | <0.001c |
| Zinc           | -0.53 | -0.61  | -0.44 | <0.001c | -0.51 | -0.59  | -0.42 | <0.001c | -0.59 | -0.64  | -0.53 | <0.001c | -0.59 | -0.65  | -0.52 | <0.001c |

a Confounding factors used in the adjusting model contained age, BMI, income, smoking status, and alcohol consumption.
b Effect estimates represented their percentage changes in association with a unit increase in FEI.
Abbreviations: TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency; NG, Neutral glucosidase.
c P<0.05.
eTable 3. Associations of FEI With Semen Quality and Biochemistry Parameters of Seminal Plasma in Different Level of GSHPx Before and After Adjusting for Confounding Factors

- Confounding factors used in the adjusting model contained age, BMI, income, smoking status, and alcohol consumption.
- Effect estimates represented their percentage changes in association with a unit increase in FEI.
- Abbreviations: TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency; NG, Neutral glucosidase.
- *P*<0.05.

|               | Low level of GSHPx |                     |                     | High level of GSHPx |                     |                     |
|---------------|-------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|               | Crude             | Adjusted            | Crude              | Adjusted            | Crude              | Adjusted            |
|               | Effect estimate  | 95%CI                | P value             | Effect estimate  | 95%CI                | P value             |
|               | lower             | higher              | lower             | higher              | lower             | higher              |
| FEI           |                   |                     |                   |                     |                   |                     |
| TSM           | -0.99             | -0.99               | -0.98             | <0.001              | -0.93             | -0.99               | 0.41               | 0.083              | -0.02             | -0.04             | 0.00               | 0.088              |
| PSM           | -0.99             | -0.99               | -0.98             | <0.001              | -0.90             | -0.99               | 0.35               | 0.082              | -0.02             | -0.04             | 0.00               | 0.073              |
| VCL           | -0.05             | -0.09               | -0.01             | 0.007               | -0.03             | -0.07               | 0.00               | 0.055              | -0.03             | -0.06             | 0.00               | 0.083              |
| VSL           | -0.08             | -0.13               | -0.03             | 0.001               | -0.04             | -0.09               | 0.00               | 0.051              | -0.04             | -0.09             | 0.00               | 0.052              |
| VAP           | -0.08             | -0.13               | -0.03             | 0.001               | -0.07             | -0.12               | -0.02             | 0.003               | -0.05             | -0.09             | 0.00               | 0.065              |
| BCF           | 0.33              | -0.11               | 1.00              | 0.172               | 0.36              | -0.06               | 0.99               | 0.109              | 0.31              | -0.10             | 0.93               | 0.160              |
| NSM           | -0.99             | -0.99               | -0.96             | <0.001              | -0.60             | -0.94               | 2.11               | 0.376              | -0.41             | -0.92             | 3.81               | 0.615              |
| DFI           | 0.16              | 0.10                | 0.21              | <0.001              | 0.02              | -0.02               | 0.07               | 0.425              | 0.01              | -0.03             | 0.06               | 0.565              |
| NG            | -0.36             | -0.47               | -0.22             | <0.001              | 0.06              | -0.15               | 0.34               | 0.582              | 0.03              | -0.18             | 0.30               | 0.778              |
| Zinc          | -0.63             | -0.68               | -0.58             | <0.001              | -0.55             | -0.62               | -0.45             | <0.001              | -0.54             | -0.62             | -0.45             | <0.001              |
### eTable 4. Effect Estimates and 95% CIs of Semen Quality Parameters With a 1-Unit Increase in FEI With and Without Adjustment for Smoking and Alcohol Consumption

| Age (year) | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | Effect estimate (%) | 95% CI | P value | Effect estimate (%) | 95% CI | P value |
| | lower | higher | | lower | higher | |
| TSM | -0.99 | -1.00 | -0.98 | <0.001<sup>b</sup> | -0.99 | -1.00 | -0.99 | <0.001<sup>b</sup> |
| PSM | -0.99 | -0.99 | -0.98 | <0.001<sup>b</sup> | -0.99 | -1.00 | -0.98 | <0.001<sup>b</sup> |
| VCL | -0.05 | -0.08 | -0.02 | <0.001<sup>b</sup> | -0.06 | -0.09 | -0.03 | <0.001<sup>b</sup> |
| VSL | -0.08 | -0.11 | -0.04 | <0.001<sup>b</sup> | -0.09 | -0.14 | -0.05 | <0.001<sup>b</sup> |
| VAP | -0.08 | -0.11 | -0.04 | <0.001<sup>b</sup> | -0.09 | -0.14 | -0.05 | <0.001<sup>b</sup> |
| BCF | 0.57 | 0.18 | 1.08 | 0.003<sup>b</sup> | 0.53 | 0.18 | 1.01 | 0.007<sup>b</sup> |
| NSM | -0.98 | -0.99 | -0.93 | <0.001<sup>b</sup> | -0.98 | -0.99 | -0.93 | <0.001<sup>b</sup> |
| DFI | 0.10 | 0.06 | 0.14 | <0.001<sup>b</sup> | 0.12 | 0.07 | 0.12 | <0.001<sup>b</sup> |
| NG | -0.24 | -0.35 | -0.10 | 0.009<sup>b</sup> | -0.33 | -0.52 | -0.12 | 0.015<sup>b</sup> |
| Zinc | -0.61 | -0.65 | -0.56 | <0.001<sup>b</sup> | -0.53 | -0.66 | -0.50 | <0.001<sup>b</sup> |

Model 1: This model was analyzed adjusting for confounding factors including age, BMI, income, smoking status, and alcohol consumption.
Model 2: This model was analyzed adjusting for confounding factors including age, BMI, income.

<sup>a</sup> Effect estimates represented their percentage changes in association with a unit increase in FEI.
<sup>b</sup> Abbreviations: TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency; NG, Neutral glucosidase.

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**eTable 5. Effect Estimates and 95% CIs of Semen Quality Parameters Associated With a 1-Unit Increase in FEI in Each Subgroup**

| Age (year) | ≥24 (underweight or normal) | ≥24 (overweight or obese) |
|------------|-----------------------------|---------------------------|
| BMI        |                             |                           |
| Effect estimate (%) | 95% CI | Effect estimate (%) | 95% CI | Effect estimate (%) | 95% CI | Effect estimate (%) | 95% CI | Effect estimate (%) | 95% CI | Effect estimate (%) | 95% CI |
| TSM        | -0.99 | -1.00 | -0.97 | <0.001* | -0.99 | -1.00 | -0.96 | <0.001* | -0.99 | -1.00 | -0.98 | <0.001* |
| PSM        | -0.99 | -0.99 | -0.95 | <0.001* | -0.99 | -0.99 | -0.93 | <0.001* | -0.99 | -0.99 | -0.95 | <0.001* |
| VCL        | -0.05 | -0.08 | -0.01 | <0.001* | -0.05 | -0.09 | -0.00 | 0.032* | -0.05 | -0.09 | -0.01 | <0.001* |
| VSL        | -0.07 | -0.11 | -0.03 | <0.001* | -0.07 | -0.13 | -0.01 | 0.014* | -0.09 | -0.13 | -0.04 | <0.001* |
| VAP        | -0.07 | -0.11 | -0.03 | <0.001* | -0.08 | -0.13 | -0.02 | 0.013* | -0.09 | -0.13 | -0.04 | <0.001* |
| BCF        | 0.52  | 0.09  | 1.13  | 0.007* | 0.52  | -0.06 | 1.48  | 0.090  | 1.05  | 0.36  | 2.08  | <0.001* |
| NSM        | -0.96 | -0.99 | -0.80 | <0.001* | -0.98 | -0.99 | -0.92 | <0.001* | -0.97 | -0.99 | -0.85 | <0.001* |
| DFI        | 0.08  | 0.04  | 0.13  | <0.001* | 0.13  | 0.07  | 0.20  | <0.001* | 0.11  | 0.06  | 0.17  | <0.001* |
| NG         | -0.18 | -0.32 | -0.01 | 0.033* | -0.32 | -0.49 | -0.09 | 0.014* | -0.30 | -0.44 | -0.12 | <0.012* |
| Zinc       | -0.58 | -0.64 | -0.51 | <0.001* | -0.65 | -0.71 | -0.58 | <0.001* | -0.61 | -0.67 | -0.53 | <0.001* |

* This model was analyzed adjusting for confounding factors including age, BMI, income, smoking status, and alcohol consumption.

Effect estimates represented their percentage changes in association with a unit increase in FEI.

Abbreviations: TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency; NG, Neutral glucosidase.

*P < 0.05.
# Figure 1. Flowchart of Participant Recruitment

#1: 15 individuals were excluded, of which 4 participants lived in newly built or decorated rooms, 6 participants had genital abnormalities or other chronic diseases, and 5 participants did not complete the questionnaires.

#2: 17 individuals were excluded, of which 3 participants lived in newly built or decorated rooms, 5 participants had genital abnormalities or other chronic diseases, and 9 participants did not complete the questionnaires.

#3: 8 individuals were excluded since the incomplete collection of semen.

#4: 4 individuals were excluded since the incomplete collection of semen.
eFigure 2. Distribution of Sociodemographic Characteristics With and Without FA Exposure

Abbreviations: BMI, body mass index.

ns: $P>0.05$. 
eFigure 3. Percentage Changes in Semen Quality Associated With a 1-Unit Increase in FEI Before and After Adjusting for Confounding Factors

(A) conventional sperm parameters, (B) kinematic sperm parameters, (C) sperm morphology and DNA fragmentation index, (D) biochemistry parameters in seminal plasma.

Abbreviations: SV, semen volume; SC, sperm concentration; TSC, total sperm count; TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; LIN, linearity; VAP, average path velocity; STR, straightness; MAD, mean angular displacement; WOB, wobble; ALH, amplitude of lateral head displacement; BCF, beat cross frequency; APC, acid phosphatase; NG, Neutral glucosidase.

***: $P<0.005$, ****: $P<0.001$. 

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eFigure 4. Heatmap of the Associations Between FEI and Semen Quality in Different Groups of Antioxidant Defenses Before and After Adjusting for Confounding Factors

Blue indicated that a unit increase in FEI was associated with a significant decrease in this factor, pink indicated that a unit increase in FEI was associated with a significant increase in this factor, white indicated that a unit increase in FEI was not associated with this factor.

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Abbreviations: TSM, total sperm motility; PSM, progressive sperm motility; NSM, normal sperm morphology; DFI, DNA fragmentation index; VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency; NG, Neutral glucosidase.
eFigure 5. Distribution of Semen Quality With and Without Occupational FA Exposure

Abbreviations: SV, semen volume; SC, sperm concentration; TSC, total sperm count; LIN, linearity; STR, straightness; MAD, mean angular displacement; WOB, wobble; ALH, amplitude of lateral head displacement; ACP, acid phosphatase.

****: \( P < 0.001 \).

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eFigure 6. Significant Associations of FEI With Kinematic Sperm Parameters

In all graphs, solid curves indicate beta and shaded areas indicate 95% CIs.

Abbreviations: VCL, curvilinear velocity; VSL, straight line velocity; VAP, average path velocity; BCF, beat cross frequency.