**Supplementary Table 1**. Detail of univariate and multivariable GAM for semen parameters in different study populations.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Study population | Type of model |  | Smooth terms | Age | Abstinence Time | Linear terms | Cities |
| Subpopulation Ⅰ | Univariate GAM model | Concentration | edf | 1.595 | 1.834 | Estimeate | 8.75 |
|  | F | 16.76 | 15.88 | SE | 0.288 |
|  | P | ＜0.001\* | ＜0.001\* | P | ＜0.001\* |
| Motility | edf | 3.935 | 2.948 | Estimeate | 25.664 |
|  | F | 17.91 | 1.576 | SE | 1.144 |
|  | P | ＜0.001\* | 0.189 | P | ＜0.001\* |
| Morphology | edf | 3.585 | 1.827 | Estimeate | 0.745 |
|  | F | 3.585 | 3.671 | SE | 0.073 |
|  | P | 0.005\* | 0.0247\* | P | ＜0.001\* |
| Multivariate GAM model | Concentration | edf | 2.452 | 1.975 | Estimeate | 8.897 |
|  | F | 3.168 | 8.416 | SE | 0.302 |
|  | P | 0.022\* | ＜0.001\* | P | ＜0.001\* |
| Motility | edf | 3.432  | - | Estimeate | 24.838 |
|  | F | 5.36 | - | SE | 1.196 |
|  | P | ＜0.001\* | - | P | ＜0.001\* |
| Morphology | edf | 3.672 | 1.611 | Estimeate | 0.764 |
|  | F | 3.256 | 1.954 | SE | 0.077 |
|  | P | 0.008\* | 0.154 | P | ＜0.001\* |
| Subpopulation Ⅱ | Univariate GAM model | Concentration | edf | 4.685 | 1 | Estimeate | 8.754 |
|  | F | 1.388 | 120.9 | SE | 0.287 |
|  | P | 0.216 | ＜0.001 | P | ＜0.001 |
| Motility | edf | 3.604 | 1.38 | Estimeate | 0.378 |
|  | F | 7.729 | 0.717 | SE | 0.023 |
|  | P | ＜0.001 | 0.338 | P | ＜0.001 |
| Morphology | edf | 1 | 1.651 | Estimeate | 0.003 |
|  | F | 2.971 | 0.631 | SE | 0.001 |
|  | P | 0.085 | 0.544 | P | ＜0.001 |
| Multivariate GAM model | Concentration | edf | - | 1 | Estimeate | 1.046 |
|  | F | - | 111.4 | SE | 0.053 |
|  | P | - | ＜0.001 | P | ＜0.001 |
| Motility | edf | 1.917 | - | Estimeate | 0.367 |
|  | F | 2.789 | - | SE | 0.024 |
|  | P | 0.049 | - | P | ＜0.001 |
| Morphology | edf | - | - | Estimeate | 0.003 |
|  | F | - | - | SE | 0.001 |
|  | P | - | - | P | ＜0.001 |

Note: \*, P＜0.05. edf, effective degrees of freedom of the smooth function terms (edf >1 indicate nonlinear relationships, edf=1 indicate linear relationship). F, an approximate F-test. Estimeate, the correlation coefficient of the variable. SE, asymptotic standard error.