**Supplemental Material**

**Supplemental Table 1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Women** | **N** | **Men** | **N** | **P-value** |
| **BV (ml)** | 5095 ±594 | 21 | 7164 ± 1253 | 86 | <0.001 |
| **BV (ml·kg-1 body mass)** | 82.7 ±7.3 | 21 | 94.4 ± 8.1 | 86 | <0.001 |
| **BV (ml·kg-1 LBM)** | 107.0 ±7.4 | 9 | 111.5 ± 6.9 | 57 | 0.125 |
| **BV (ml·m-2 BSA)** | 2748 ± 241 | 18 | 3317 ± 353 | 82 | <0.001 |
| **RBCV (ml)** | 2115 ± 273 | 21 | 3136 ± 521 | 86 | <0.001 |
| **RBCV (ml·kg-1 body mass)** | 34.3 ±3.7 | 21 | 41.4 ± 3.6 | 86 | <0.001 |
| **RBCV (ml·kg-1 LBM)** | 43.7 ±3.1 | 9 | 48.4 ± 3.4 | 57 | 0.002 |
| **RBCV (ml·m-2 BSA)** | 1147 ± 123 | 18 | 1451 ± 156 | 82 | <0.001 |
| **PV (ml)** | 2981 ± 358 | 21 | 4028 ± 785 | 86 | <0.001 |
| **PV (ml·kg-1 body mass)** | 48.4 ± 4.5 | 21 | 53.1 ± 5.7 | 86 | <0.001 |
| **PV (ml·kg-1 LBM)** | 63.3 ± 5.0 | 9 | 63.1 ± 5.6 | 57 | 0.890 |
| **PV (ml·m-2 BSA)** | 1601 ± 145 | 18 | 1866 ± 235 | 82 | <0.001 |
| **Hbmass (g)** | 706 ± 90 | 21 | 1048 ± 162 | 86 | <0.001 |
| **Hbmass (g·kg-1 body mass)** | 11.4 ± 1.1 | 21 | 13.8 ± 1.1 | 86 | <0.001 |
| **Hbmass (g·kg-1 LBM)** | 14.9 ± 0.8 | 9 | 16.2 ± 1.1 | 57 | 0.001 |
| **Hbmass (g·m-2 BSA)** | 383 ± 36 | 18 | 485 ± 46 | 82 | <0.001 |
| **[Hb] (g·dl-1)** | 13.9 ± 0.6 | 21 | 15.1 ± 1.0 | 86 | <0.001 |
| **Hematocrit (%)** | 41.5 ± 2.1 | 21 | 44.7 ± 2.5 | 86 | <0.001 |

**Hematological characteristics of female and male adult athletes** BSA: body surface area; BV: blood volume; [Hb]: hemoglobin concentration; Hbmass: hemoglobin mass; LBM: lean body mass; PV: plasma volume; RBCV: red blood cell volume. Mean ± SD

**Supplemental Tables 2A-D**

***Results of best subset multiple regression analyses***

1. *Model 1: clinical prediction of blood volume*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Predictor number | Predictors | R2 | Adjusted R2 | C(p) | AIC |
| 1 | LBM | 0.715 | 0.714 | 8.39 | 6435 |
| 2 | LBM, age | 0.724 | 0.723 | -1.57 | 6393 |
| 3 | LBM, age, height | 0.730 | 0.728 | -7.89 | 6387 |
| 4 | LBM, age, height, weight | 0.730 | 0.728 | -6.20 | 6357 |
| 5 | LBM, age, height, weight, sex | 0.731 | 0.727 | -4.74 | 6359 |
| 6 | LBM, age, height, weight, sex, VO2max | 0.721 | 0.714 | 7.00 | 4057 |

1. *Model 2: simple prediction of blood volume*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Predictor number | Predictors | R2 | Adjusted R2 | C(p) | AIC |
| 1 | Sex | 0.504 | 0.503 | 260.7 | 8466 |
| 2 | Sex, weight | 0.616 | 0.615 | 85.77 | 8302 |
| 3 | Sex, weight, height | 0.655 | 0.654 | 26.42 | 8248 |
| 4 | Sex, weight, height, age | 0.671 | 0.669 | 5.00 | 8195 |

1. *Model 3: clinical prediction of hemoglobin mass*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Predictor number | Predictors | R2 | Adjusted R2 | C(p) | AIC |
| 1 | LBM | 0.793 | 0.792 | 30.15 | 4823 |
| 2 | LBM, sex | 0.812 | 0.811 | -9.57 | 4784 |
| 3 | LBM, sex, height | 0.815 | 0.813 | -12.41 | 4781 |
| 4 | LBM, sex, height, age | 0.816 | 0.814 | -12.40 | 4757 |
| 5 | LBM, sex, height, age, weight | 0.816 | 0.814 | -10.66 | 4736 |
| 6 | LBM, sex, height, age, weight, VO2max | 0.798 | 0.794 | 7.00 | 3028 |

1. *Model 4: simple prediction of hemoglobin mass*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Predictor number | Predictors | R2 | Adjusted R2 | C(p) | AIC |
| 1 | Sex | 0.659 | 0.658 | 253.3 | 6403 |
| 2 | Sex, weight | 0.738 | 0.737 | 76.5 | 6243 |
| 3 | Sex, weight, height | 0.771 | 0.769 | 3.75 | 6175 |
| 4 | Sex, weight, height, age | 0.771 | 0.770 | 5.00 | 6153 |

AIC: Akaike Information Criteria; C(p): Mallow’s Cp; LBM: lean body mass; VO2max: maximal oxygen uptake

**Supplemental Table 3**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Reference** | **N** | **CO rebreathing** | | | **Body composition** | | | **VO2max** |
| **10 min manual** | **10 min Detalo** | **2 min** | **DEXA** | **BIA** | **Skin-fold** |
| **Dandanell et al., 2016**[52] | 13 |  | x |  | x |  |  | x |
| **Montero et al., 2017**[48] | 9 |  | x |  | x |  |  | x |
| **Diaz-Canestro et al., 2021**[53] **and 2022**[54-56] | 73 | x |  |  | x |  |  | x |
| **Siebenmann et al., 2015**[57] | 9 | x |  |  | x |  |  | x |
| * **Almquist et al., 2020**[58] **and 2021**[59] | 23 |  | x |  | x |  |  | x |
| **Cepeda-Lopez et al., 2019**[9] | 62 |  |  | x | x |  |  |  |
| **Robach et al., 2021**[60] | 22 | x |  |  |  |  |  |  |
| **Lundby & Robach, 2015**[40] | 9 | x |  |  |  |  |  | x |
| **Jelkmann & Lundby, 2011**[44] | 29 | x |  |  |  |  |  | x |
| * **Lundby et al., 2018**[3] | 5 |  | x |  | x |  |  |  |
| * **Treff et al., 2014**[21] | 15 |  |  | x |  |  | x | x |
| * **Lundgren et al., 2021**[22] | 50 |  |  | x |  | X |  | x |
| * **Unpublished (a)** | 76 | x |  |  | x |  |  | x |
| * **Sjurdarson et al., 2022[61]** | 42 |  |  | x | x |  |  | x |
| * **Unpublished (b)** | 33 |  | x |  | x |  |  | x |
| * **Unpublished (c)** | 46 |  | x |  | x |  |  |  |
| * **Unpublished (d)** | 29 |  |  | x | x |  |  | x |
| * **Unpublished (e)** | 59 |  |  | x | x |  |  | x |
| **Unpublished (f)** | 7 |  | x |  | x |  |  | x |
| **Breenfeldt-Andersen et al., 2023[62]** | 45 |  |  | x | x |  |  | x |
| **Bonne et al., 2022[63]** | 33 |  |  | x | x |  |  | x |

**Overview of the included variables.** auto:automated; Bio:bio-impedance; CO: carbon monoxide; DEXA: dual energy x-ray absorptiometry; VO2max: maximal oxygen uptake.

**Supplemental Table 4**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Women (n=263)** | **Men (n=319)** | **Total (n=582)** |
| **Age, years** | Mean (min-max) | 36.6 (9.7-93.0) | 38.9 (9.5-86.0) | 37.8 (9.5-93.0) |
| **<20** | N (%) | 33 (12.5) | 40 (12.5) | 73 (12.5) |
| **20-30** | N (%) | 122 (46.4) | 119 (37.3) | 241 (41.4) |
| **30-40** | N (%) | 26 (9.9) | 40 (12.5) | 66 (11.3) |
| **40-50** | N (%) | 18 (6.8) | 36 (11.3) | 54 (9.3) |
| **50-60** | N (%) | 8 (3.0) | 6 (1.9) | 14 (2.4) |
| **60-70** | N (%) | 21 (8.0) | 33 (10.3) | 54 (9.3) |
| **>70** | N (%) | 34 (12.9) | 44 (13.8) | 78 (13.4) |
| **Body mass (kg)** | Mean (min-max) | 65.5 (29.8-113) | 76.4 (26.2-119) | 71.5 (26.2-119) |
| **Height (m)** | Mean (min-max) | 1.66 (1.38-1.87) | 1.78 (1.35-1.96) | 1.73 (1.35-1.96) |
| **BMI (kg∙m-2)** | Mean (min-max) | 23.7 (15.5-40.6) | 24.0 (14.3-38.5) | 23.8 (14.3-40.6) |
| **<20** | N (%) | 42 (16.0) | 29 (9.1) | 71 (12.2) |
| **20-25** | N (%) | 140 (53.2) | 185 (58.0) | 325 (55.8) |
| **25-30** | N (%) | 52 (19.8) | 88 (27.6) | 140 (24.1) |
| **>30** | N (%) | 27 (10.3) | 17 (5.3) | 44 (7.6) |
| **Body surface area (m2)** | Mean (min-max) | 1.86 (1.18-2.40) | 2.09 (1.10-2.62) | 1.99 (1.10-2.62) |
| **Body fat (%)** | Mean (min-max) | 31.7 (14.9-53.1) | 20.3 (8.1-43.7) | 25.7 (8.1-53.1) |
| **Lean body mass (kg)** | Mean (min-max) | 41.3 (19.8-60.0) | 57.9 (20.0-82.9) | 50.0 (19.8-82.9) |
| **VO2max (ml/min/kgBM)** | Mean (min-max) | 39.1 (18.0-59.6) | 45.9 (18.9-69.9) | 43.2 (18.0-69.9) |

**Characteristics of all the included, non-athletic individuals.** BM: body mass; BMI: body mass index; VO2max: maximal oxygen uptake (nTotal=402)

**Supplemental figure captions**

**Supplemental Figure 1. Effect of carbon monoxide rebreathing method on hemoblogin mass per lean mass.** In non-athletic individuals including children, one-way anova revealed an effect of methods on hemoglobin mass per lean mass. n=436. LBM: lean body mass

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**Supplemental Figure 2. Linear relationship between age and blood parameters.** A) Blood volume, B) Red blood cell volume, C) Plasma volume, D) Hemoglobin mass. Each dot represents one individual: n=523.

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Automatisk generert beskrivelse

**Supplemental Figure 3. Linear relationship between age and [Hb] and hematocrit.** A) [Hb], B) Hematocrit. Each dot represents one individual: n=523. [Hb]: hemoglobin concentration.

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Automatisk generert beskrivelse

**Supplemental Figure 4. Relationship between absolute VO2max and blood parameters.** A) Blood volume, B) Red blood cell volume, C) Plasma volume, D) Hemoglobin mass. Each dot represents one individual: n=499; including all children, healthy adult and athletes in whom VO2max testing was performed.

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**Supplemental Figure 5. Relationship between relative (LBM) VO2max and blood parameters.** A) Blood volume, B) Red blood cell volume, C) Plasma volume, D) Hemoglobin mass. Each dot represents one individual: n=499; including all children, healthy adult and athletes in whom VO2max testing was performed.

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**Supplemental Figure 6. Relationship between Body Mass Index (BMI) and blood parameters.**

A) Blood volume, B) Red blood cell volume, C) Plasma volume, D) Hemoglobin mass. Each dot represents one individual: n=582; including all children and healthy adult. Women: BV and BMI: R2=0.20, p<0.0001; RBCV and BMI: R2=0.17, p<0.0001; PV and BMI: R2=0.19, p<0.0001; Hbmass and BMI: R2=0.22, p<0.0001. Men: BV and BMI: R2=0.20, p<0.0001; RBCV and BMI: R2=0.20, p<0.0001; PV and BMI: R2=0.15, p<0.0001; Hbmass and BMI: R2=0.21, p<0.0001.

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**Supplemental Figure 7. Comparison of measured to predicted blood volumes in all non-athletic individuals (adults only) visualized by Bland-Altman plots.** For all measured blood volumes in the present study, the predicted blood volume was calculated and subtracted from the measured (y-axis) and plotted against the mean of the measured and the predicted blood volume (x-axis). A) Prediction made by the Nadler formula (nTotal=582); B) Prediction made from age, body mass and height based on the current data (nTotal=582); C) Prediction made from age, height and lean mass based on the current data (nTotal=469). The black line indicates the mean difference between the measured and the predicted blood volume. The red, dashed lines indicate the 95% limits of agreement.

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