# The Relationship of Handgrip to Body Composition and Cardiopulmonary Fitness in Children and Young Adults


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## Introduction

- Handgrip Strength (HGS) is a quantitative measure of muscle function. It is non-invasive, inexpensive, and fast to obtain
- Regular measurement of HGS rarely occurs in pediatric cardiac centers
- In pediatric patients, HGS is associated with bone health, spirometry, and metrics of cardiovascular health
- HGS is a risk factor for unfavorable health outcomes and is associated with all-cause mortality and cardiovascular diseases (CVD) in both adults and adolescents
- Research into HGS and its relationship with fitness and body composition is lacking

## Objectives

- Describe the HGS values in a large cohort of youth and young adults with normal cardiac anatomy
- Assess the relationship of HGS with markers of fitness on CPET and body composition assessed by BIA
- Describe differences in HGS by sex

## Methods

- Single-site
- Retrospective chart review of all patients from January 2020 to June 2023 who completed HGS, BIA, and CPET
- Exclusion criteria: age <25 years, incomplete data, submaximal effort tests, or known cardiovascular disease
- CPET data, size, and baseline demographic data recorded (Table 1)
- Body composition obtained using bioelectrical impedance analysis (BIA; InBody370) (Table 1)
- Handgrip measures on each hand, was performed 3 times using a hydraulic handgrip manometer (BL5001; B&L Engineering) (Table 1)
- Pearson's correlation was used to assess the relationship between HG and BIA/CPET results
- A student's T-test was performed to assess differences between male and female patients
- P < 0.05 considered significant
- Multivariable analysis was done to assess for independent predictors of dominant hand grip with candidate predictors for the model being age, size, and body composition measures with a p<0.1
- Data is presented as a mean ± standard deviation

| | Total Cohort N=317 | Males N=117 | Females N=200 | P value |
|---|---|---|---|---|
| **Age (yr)** | 15.1±2.4 | 14.7±2.7 | 15.5±2.1 | 0.001 |
| **Handgrip (kg)** | | | | |
| **Peak R HG (kg)** | 30.0±9.3 | 34.4±11.6 | 27.5±6.3 | <0.0001 |
| **Peak L HG (kg)** | 27.9±9.1 | 32.4±11.1 | 25.4±6.3 | <0.0001 |
| **Peak Dominant HG (kg)** | 28.3±9.2 | 32.8±11.4 | 25.8±5.8 | <0.0001 |
| **Peak Non-Dominant HG (kg)** | 28.0±9.0 | 32.4±11.1 | 25.5±6.0 | <0.0001 |
| **Bioelectrical Impedance Analysis** | | | | |
| **Height (cm)** | 165.0±10.8 | 168.1±14.2 | 163.5±7.8 | 0.0003 |
| **Weight (kg)** | 60.8±16.5 | 62.5±20.3 | 60.5±14.3 | 0.4 |
| **Skeletal Muscle Mass (kg)** | 25.3±6.3 | 28.6±8.4 | 23.7±4.0 | <0.0001 |
| **Body Fat Mass (kg)** | 15.0±10.3 | 11.4±10.3 | 17.7±10.1 | <0.0001 |
| **Body Fat Percentage (%)** | 23.2±10.3 | 16.7±9.6 | 27.4±8.6 | <0.0001 |
| **Body Mass Index (kg/m²)** | 22.1±5.0 | 21.7±5.2 | 22.7±5.0 | 0.1 |
| **Right Arm Lean Mass (kg)** | 2.3±0.8 | 2.7±1.0 | 2.1±0.5 | <0.0001 |
| **Left Arm Lean Mass (kg)** | 2.3±0.7 | 2.7±1.0 | 2.1±0.5 | <0.0001 |
| **Trunk Lean Mass (kg)** | 20.5±4.9 | 22.6±6.2 | 19.2±3.1 | <0.0001 |
| **Right Leg Lean Mass (kg)** | 7.0±1.8 | 7.9±2.3 | 6.5±1.2 | <0.0001 |
| **Left Leg Lean Mass (kg)** | 6.9±1.7 | 7.8±2.3 | 6.5±1.2 | <0.0001 |
| **CPET** | | | | |
| **$VO_2$peak (ml/min)** | 2163.0±633.3 | 2507±760.5 | 1938.3±454.6 | <0.0001 |
| **$VO_2$peak (ml/min/kg)** | 36.4±8.7 | 41.3±8.7 | 32.6±7.2 | <0.0001 |
| **$VO_2$peak (percent predicted)** | 95.7±19.2 | 88.9±18.5 | 97.3±19.1 | <0.0001 |
| **Peak HR (bpm)** | 185.8±9.3 | 182.2±13.1 | 183.5±11.6 | 0.4 |
| **Peak Work (watts)** | 151.3±49.6 | 174.7±64.4 | 136.4±34.5 | <0.0001 |
| **Peak SBP (mmHg)** | 171.1±21.1 | 174.6±25.9 | 168.0±17.4 | 0.008 |
| **RER** | 1.2±0.09 | 1.2±0.08 | 1.2±0.1 | 0.5 |
| **VAT (%)** | 63.3±15.8 | 60.0±15.8 | 63.7±15.4 | 0.04 |

**Table 1:** Results of handgrip, bioelectrical impedance analysis, and cardiopulmonary exercise testing in otherwise healthy patients <25 years of age.Data presented as mean±standard deviation [range].

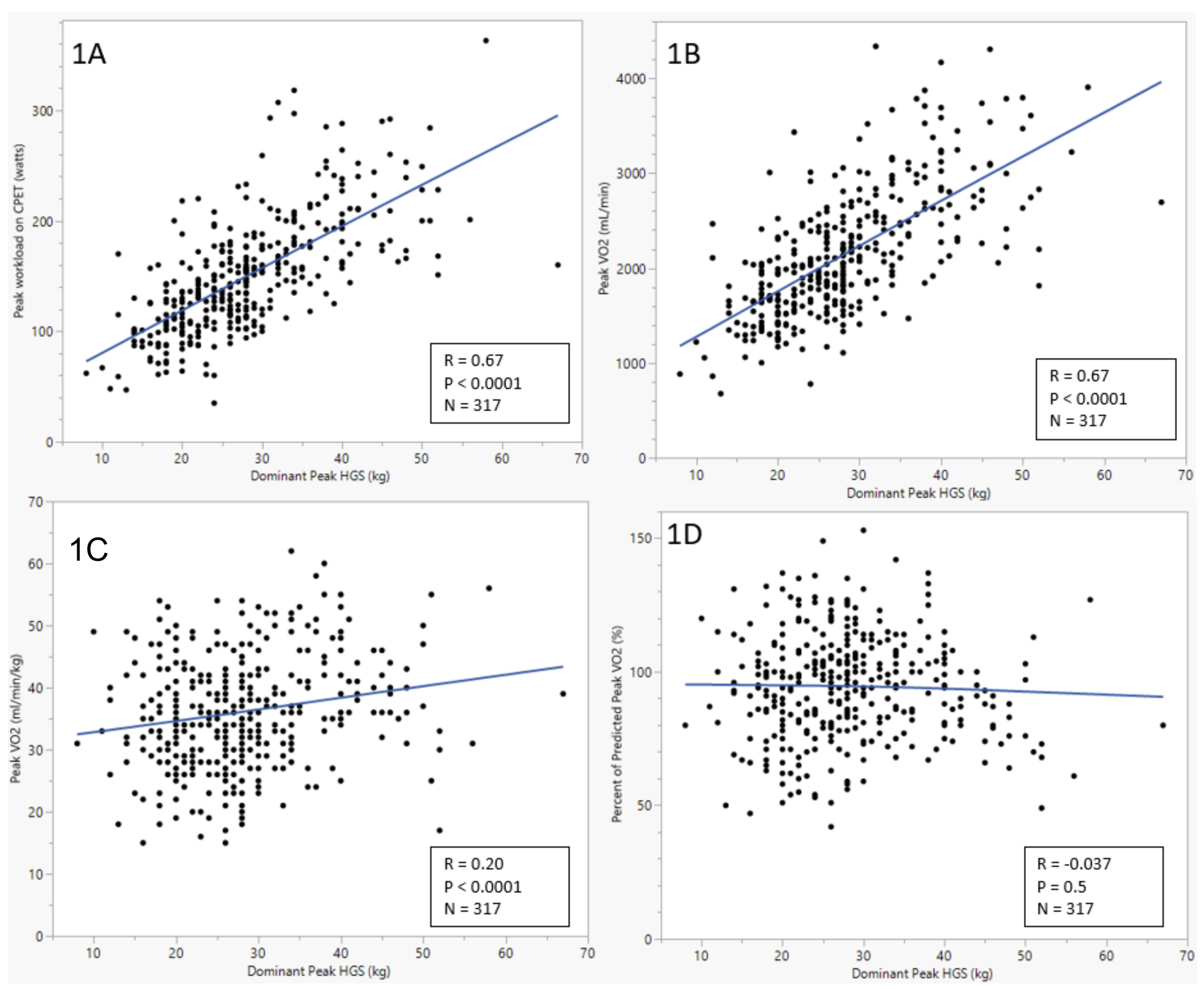


**Figure 1:** Relationship between dominant peak HGS and fitness outcomes, including peak workload (1A), VO2peak (mL/min) (1B), VO2peak (mL/min/kg)(1C), and percent of predicted VO2peak (1D).

| Univariable Analysis | R | p-value |
|---|---|---|
| **Age (yr)** | 0.43 | <0.0001 |
| **Height (cm)** | 0.64 | <0.0001 |
| **Weight (kg)** | 0.52 | <0.0001 |
| **BMI (kg/m²)** | 0.27 | <0.0001 |
| **SMM (kg)** | 0.77 | <0.0001 |
| **Body Fat Mass (kg)** | 0.063 | 0.3 |
| **Body Fat Percentage** | -0.19 | 0.008 |
| **R Arm Lean Mass (kg)** | 0.76 | <0.0001 |
| **L Arm Lean Mass (kg)** | 0.76 | <0.0001 |
| **R Leg Lean Mass (kg)** | 0.76 | <0.0001 |
| **L Leg Lean Mass (kg)** | 0.75 | <0.0001 |
| **pVO2 (ml/min)** | 0.67 | <0.0001 |
| **pVO2 (ml/min/kg)** | 0.20 | 0.0004 |
| **pVO2 (% predicted)** | -0.037 | 0.5 |
| **Work (watts)** | 0.67 | <0.0001 |
| **pHR (bpm)** | -0.069 | 0.2 |
| **pSBP (mmHg)** | 0.48 | <0.0001 |
| **VAT (%)** | -0.12 | 0.045 |
| **Non-Dominant HG (kg)** | 0.99 | <0.0001 |
| **Multivariable Analysis** | Standard-b Coefficient (parameter estimates) | P value |
| **SMM, per kg** | 1.2 (1.7±0.29) | <0.0001 |
| **Age, per year** | 0.12 (0.45±0.18) | 0.01 |
| **Weight, per kg** | -0.49 (-0.25±0.12) | 0.03 |
| **Height, per cm** | -0.15 (-0.13±0.06) | 0.04 |
| **Body fat, per 1%** | 0.11 (0.09±0.12) | 0.4 |

**Table 2:** Correlation between peak dominant hand grip strength and outcomes variables in otherwise healthy patients <25 years of age.

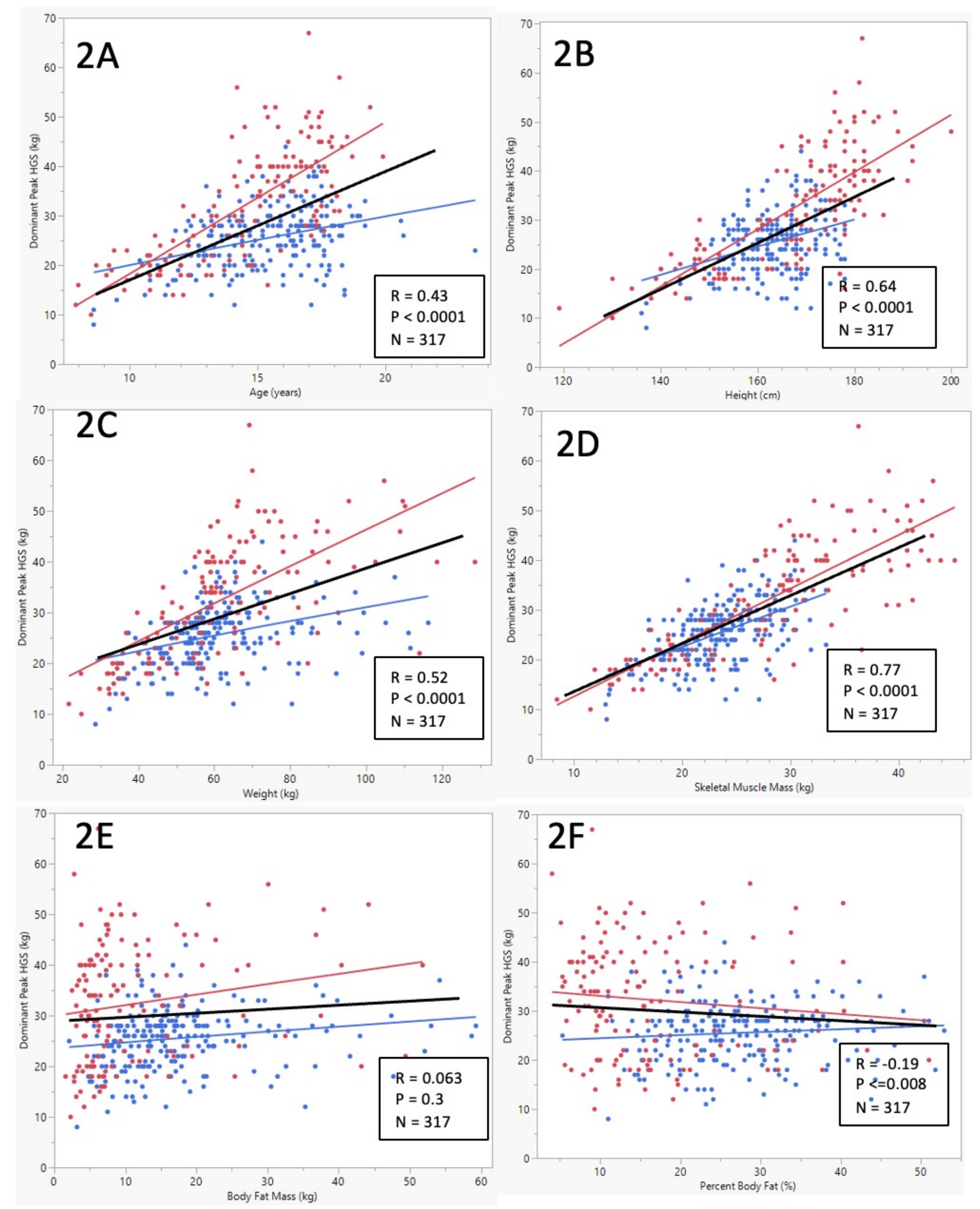


**Figure 2:** Relationship between dominant peak HGS and age (2A), height (2B), weight (2C), and skeletal muscle mass assessed by bioelectrical impedance analysis (2D), body fat mass assessed by BIA (2E), and body fat percentage assessed by BIA (2F). Black indicates all patients, red indicates male patients, and blue indicates female patients.

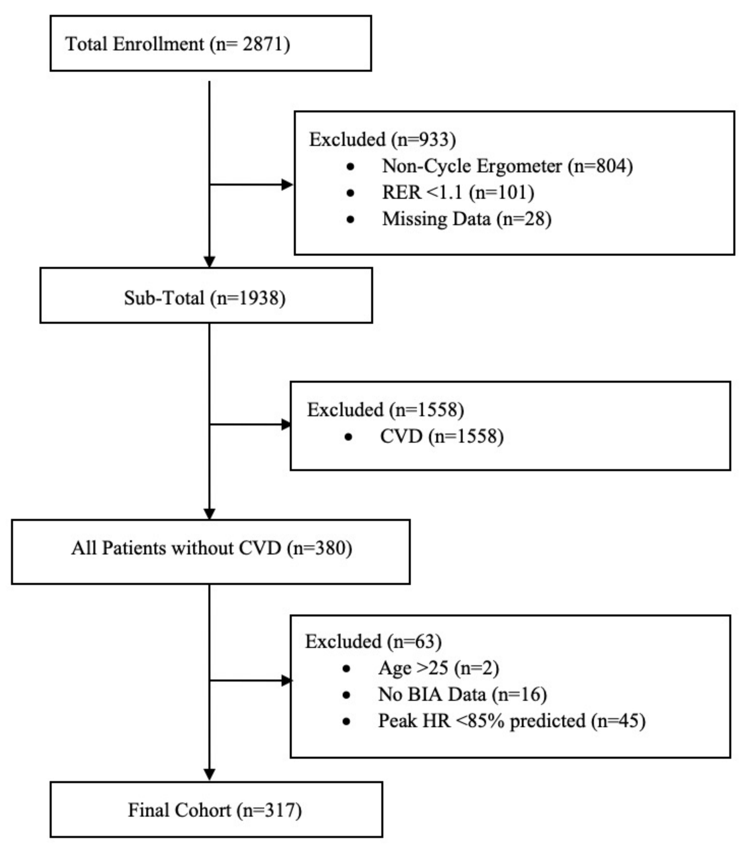


**Figure 3**: Flowsheet of total enrollment with application of the exclusion criteria to demonstrate cohort selection.

## Results

- 2871 patients completed HGS, BIA, and CPET Following the application of our inclusion/exclusion criteria there were 317 patients with complete data and presumably normal hearts (Figure 3)
- The mean age was 15.1 ± 2.4 years old (37% male)
- On BIA, the weight (60.8 ± 16.5 kg), SMM (25.3±6.3 kg), body fat mass (15.0±10.3 kg), body fat percentage (23.2%±10.3%), and body mass index (22.1±5.0 kg/m2) were recorded
- Peak handgrip was correlated with skeletal muscle mass (R=0.77, p<0.0001), peak VO2 (ml/min) (R= 0.67, p<0.0001), and work (R= 0.67, p<0.0001)
- Peak dominant handgrip strength had a negative relationship with body fat percentage (R= -0.19, p=0.008) and was not related to body fat mass (R=0.063, p<0.3)
- At young ages, the HGS was similar between the sexes but diverged in the teenage years; however, when comparing the relationship between SMM and sex, there was no difference in HGS between male and female patients with similar SMM.

## Conclusion

- HGS is associated with skeletal muscle mass, total work, and absolute measured VO2peak, but not measures of adiposity.
- Sex based differences in HGS values occur in mid-teenage years, likely secondary to expectant pubertal changes.


## Acknowledgements

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