**Supplementary Digital Content**

Age-related Differences for Cardiorespiratory Fitness Improvement in Patients Undergoing Cardiac Rehabilitation

**Table S1:** Patient Demographics by Age Decade

**Table S2:** Exercise Testing Variables by Age Decade

**Table S3**: Baseline Peak VO2 and Changes in Peak VO2 for Specific Cardiac Rehabilitation Indications

Table S1: Patient Demographics by Age Decade

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Demographic variable****(Total n = 708)** | **<40yrs (n=41)** | **40-49yrs (n=74)** | **50-59yrs (n=207)** | **60-69rs (n=221)** | **70-79yrs (n=141)** | **80-89yrs (n=24)** | **p value** |
| Age (years) | 32.4 ± 5.1 | 46.0 ± 2.8  | 55.5 ± 2.8  | 65.0 ± 2.7  | 74.7 ± 2.8  | 82.3 ± 1.9  | < 0.001  |
| Female  | 14 (34%)  | 26 (35%)  | 46 (22%)  | 46 (21%)  | 27 (19%)  | 8 (33%)  | 0.035  |
| Body mass index (kg.m-2) | 29.8 ± 7.4  | 29.1 ± 5.5  | 30.2 ± 5.4  | 29.4 ± 5.3  | 29.2 ± 4.3  | 26.9 ± 4.0  | 0.067  |
| Rehab duration (weeks) | 11.3 (6.5)  | 13.8 (10.1)  | 15.2 (11.4)  | 15.7 (10.1)  | 17.3 (8.7)  | 18.2 (7.4)  | 0.007 |
| Rehab Sessions  | 22.6 (11.5)  | 24.7 (14.5)  | 24.9 (13.7)  | 27.8 (12.2)  | 30.9 (10.8)  | 30.4 (8.7)  | < 0.001  |
| **Indication for cardiac rehabilitation** |
| Acute coronary syndrome | 5 (12%)  | 22 (30%)  | 58 (28%)  | 57 (26%)  | 49 (35%)  | 5 (21%)  | 0.089 |
| PCI | 4 (10%)  | 14 (19%)  | 73 (35%)  | 68 (31%)  | 53 (38%)  | 11 (46%)  | < 0.001 |
| Surgical | 18 (44%)  | 23 (31%)  | 51 (25%)  | 58 (26%)  | 20 (14%)  | 3 (12%)  | 0.001 |
| Heart transplant | 14 (34%)  | 16 (22%)  | 40 (19%)  | 27 (12%)  | 3 (2%)  | 0 (0%)  | < 0.001 |
| CABG | 2 (5%)  | 2 (3%)  | 7 (3%)  | 14 (6%)  | 8 (6%)  | 3 (12%)  | 0.34 |
| Valve | 2 (5%)  | 4 (5%)  | 3 (1%)  | 15 (7%)  | 9 (6%)  | 0 (0%)  | 0.099 |
| Other ‡ | 14 (34%)  | 15 (20%)  | 25 (12%)  | 37 (17%)  | 19 (13%)  | 5 (21%)  | 0.013 |
| **Co-morbidities** |  |  |  |  |  |  |  |
| Myocardial infarction | 7 (17%)  | 25 (34%)  | 72 (35%)  | 81 (37%)  | 63 (45%)  | 12 (50%)  | 0.023  |
| Hypertension  | 15 (37%)  | 46 (62%)  | 160 (77%)  | 185 (84%)  | 130 (92%)  | 24 (100%)  | < 0.001  |
| Chronic heart failure  | 23 (56%)  | 25 (34%)  | 68 (33%)  | 76 (34%)  | 46 (33%)  | 10 (42%)  | 0.096  |
| Dyslipidemia  | 23 (56%)  | 60 (81%)  | 193 (93%)  | 206 (93%)  | 136 (96%)  | 24 (100%)  | < 0.001  |
| Arrhythmia  | 28 (68%)  | 50 (68%)  | 163 (79%)  | 181 (82%)  | 118 (84%)  | 21 (88%)  | 0.025  |
| Stroke  | 3 (7%)  | 12 (16%)  | 34 (16%)  | 46 (21%)  | 48 (34%)  | 10 (42%)  | < 0.001  |
| Chronic kidney disease  | 9 (22%)  | 18 (24%)  | 65 (31%)  | 68 (31%)  | 47 (33%)  | 10 (42%)  | 0.446  |
| COPD  | 3 (7%)  | 28 (38%)  | 83 (40%)  | 102 (46%)  | 63 (45%)  | 9 (38%)  | < 0.001  |
| Diabetes  | 11 (27%)  | 34 (46%)  | 123 (59%)  | 145 (66%)  | 95 (67%)  | 15 (62%)  | < 0.001  |
| Peripheral artery disease  | 0 (0%)  | 5 (7%)  | 23 (11%)  | 34 (15%)  | 23 (16%)  | 12 (50%)  | < 0.001  |
| Smoking  | 22 (54%)  | 42 (57%)  | 128 (62%)  | 153 (69%)  | 94 (67%)  | 12 (50%)  | 0.107  |
| **Medications** |  |  |  |  |  |  |  |
| β-blocker  | 20 (49%)  | 60 (81%)  | 155 (75%)  | 173 (78%)  | 122 (87%)  | 20 (83%)  | < 0.001  |
| ACE Inhibitor or AR2B  | 16 (39%)  | 35 (47%)  | 107 (52%)  | 125 (57%)  | 89 (63%)  | 17 (71%)  | 0.021  |
| Calcium channel blocker | 6 (15%)  | 17 (23%)  | 45 (22%)  | 64 (29%)  | 38 (27%)  | 9 (38%)  | 0.172  |
| Diuretics | 14 (34%)  | 25 (34%)  | 75 (36%)  | 100 (45%)  | 78 (55%)  | 13 (54%)  | 0.003  |
| Salicylates or anti-platelet  | 14 (34%)  | 52 (70%)  | 144 (70%)  | 156 (71%)  | 113 (80%)  | 22 (92%)  | < 0.001  |
| Anticoagulant | 8 (20%)  | 19 (26%)  | 29 (14%)  | 42 (19%)  | 35 (25%)  | 6 (25%)  | 0.119  |
| Cholesterol lowering  | 14 (34%)  | 55 (74%)  | 172 (83%)  | 180 (81%)  | 123 (87%)  | 22 (92%)  | < 0.001  |

Continuous data are presented as mean ± SD and categorical data presented as n (%).

Abbreviations: PCI – percutaneous coronary intervention; CABG – coronary artery bypass graft surgery; COPD – chronic obstructive pulmonary disease; ACE – angiotensin-converting enzyme; ARB – angiotensin II receptor blocker. ‡ Breakdown of other category includes stable angina (4%), heart failure (2%), dyspnea (<1%), sudden cardiac death (<1%), peripheral artery disease (<1%), pericarditis or myocarditis (<1%), or non-specified cardiac event (8%).

Table S2: Exercise Testing Variables by Age Decade

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Outcome variable****(Total n = 708)** | **<40yrs** **(n=41)** | **40-49yrs (n=74)** | **50-59yrs (n=207)** | **60-69rs (n=221)** | **70-79yrs (n=141)** | **80-89yrs (n=24)** | **p value** |
| **Baseline CPET variables** |  |  |  |  |  |
| Resting HR (beat.min-1) | 74 ± 13  | 71 ± 13 | 70 ± 11  | 68 ± 11  | 66 ± 11  | 63 ± 8  | < 0.001 |
| Resting SBP (mmHg) | 101 ± 19  | 108 ± 17  | 112 ± 18  | 116 ± 19  | 123 ± 20  | 122 ± 20  | < 0.001 |
| Resting DBP (mmHg) | 65 ± 15  | 70 ± 15  | 72 ± 12  | 71 ± 10  | 70 ± 10  | 63 ± 13  | 0.001 |
| Peak exercise HR (beat.min-1) | 139 ± 32  | 133 ± 24  | 131 ± 24  | 124 ± 21  | 119 ± 18  | 115 ± 17  | < 0.001 |
| Peak exercise SBP (mmHg) | 131 ± 37  | 147 ± 35  | 155 ± 40  | 155 ± 33  | 159 ± 31  | 151 ± 19  | < 0.001 |
| Peak exercise DBP (mmHg) | 57 ± 16  | 65 ± 19  | 65 ± 20  | 68 ± 13  | 67 ± 14  | 54 ± 24  | < 0.001 |
| Peak exercise RPE | 18.1 ± 0.9  | 18.2 ± 0.7  | 18.2 ± 1.0  | 18.2 ± 0.8  | 18.2 ± 0.8  | 18.0 ± 1.0  | 0.838 |
| Peak exercise RER  | 1.2 ± 0.1  | 1.2 ± 0.1  | 1.2 ± 0.1  | 1.2 ± 0.1  | 1.2 ± 0.1  | 1.2 ± 0.1  | 0.308 |
| Peak workload (estimated METs)  | 6.9 ± 2.2  | 7.0 ± 1.6  | 7.2 ± 1.8  | 6.7 ± 1.5  | 6.4 ± 1.4  | 6.0 ± 1.5  | < 0.001 |
| Peak absolute VO2 (L.min-1) | 1.87 ± 0.90  | 1.84 ± 0.73  | 1.98 ± 0.74 | 1.71 ± 0.56  | 1.54 ± 0.41  | 1.22 ± 0.32  | < 0.001 |
| Peak relative VO2 (mL.kg.min-1) | 20.8 ± 9.3  | 21.1 ± 7.5  | 21.6 ± 7.4  | 19.6 ± 6.2  | 18.1 ± 4.3  | 16.4 ± 3.5  | < 0.001 |
| % predicted peak VO2 (Wasserman-Hansen) | 56 ± 21 | 67 ± 20 | 76 ± 24 | 76 ± 22 | 81 ± 17 | 83 ± 15 | < 0.001 |
| % predicted peak VO2 (FRIEND-registry) | 60 ± 25  | 71 ± 26  | 80 ± 29  | 82 ± 40  | 83 ± 28  | 81 ± 22  | < 0.001 |
| Peak oxygen pulse (mL.beat-1) | 13.0 ± 5.2  | 13.6 ± 4.6  | 14.8 ± 4.5  | 13.8 ± 4.1  | 13.1 ± 3.5  | 10.7 ± 2.5  | < 0.001 |
| **Post CPET variables following cardiac rehabilitation** |
| % predicted peak VO2 (Wasserman-Hansen) | 66 ± 19 | 79 ± 22 | 84 ± 24 | 85 ± 22 | 86 ± 17 | 89 ± 18 | < 0.001 |
| % predicted peak VO2 (FRIEND-registry) | 69 ± 22 | 82 ± 27 | 87 ± 27 | 89 ± 49 | 88 ± 35 | 84 ± 23 | 0.037 |
| Delta change in peak relative VO2 (mL.kg.min-1) | 3.5 ± 4.4  | 3.8 ± 3.8  | 2.7 ± 3.8  | 2.5 ± 3.8  | 1.4 ± 3.0  | 1.0 ± 2.4  | < 0.001  |
| Percent change in peak relative VO2 (%) | 26 ± 33 | 21 ± 24  | 17 ± 28  | 18 ± 32  | 9 ± 20  | 6 ± 15  |  0.001\* |
| Delta change in peak workload (METs) | 0.9 ± 1.2  | 1.0 ± 1.2  | 0.7 ± 1.1  | 0.7 ± 1.1  | 0.6 ± 1.1 | 0.4 ± 1.3  | 0.126 |
| Percent change in peak workload (%) | 18 ± 26  | 17 ± 22  | 13 ± 21  | 14 ± 27  | 11 ± 21 | 11 ± 25  | 0.545 |
| Proportion of VO2 responders (n, %) | 34 (83%)  | 65 (88%)  | 161 (78%)  | 170 (77%)  | 101 (72%)  | 15 (62%)  | 0.052 |

Continuous data are presented as mean ± SD and categorical data presented as n (%).

\*Post-hoc comparisons revealed significant differences (p<0.05) between <40yrs group and all other age groups.

Abbreviations: CPET – cardiopulmonary exercise test; HR – heart rate; SBP – systolic blood pressure; DBP – diastolic blood pressure; RPE – rating of perceived exertion; RER – respiratory exchange ratio; METs – metabolic equivalent; VO2 – oxygen uptake

Table S3: Baseline Peak VO2 and Changes in Peak VO2 for Specific Cardiac Rehabilitation Indications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Outcome variable** | **Total**  | **Younger adults**  | **Midlife adults** | **Older adults** |
| **Total cohort** | **n=708** | **n=115**  | **n=324** | **n=269** |
| Peak relative VO2 (mL.kg.min-1) | 20.0 ± 6.7 | 21.0 ± 8.1 | 21.1 ± 7.1  | 18.2 ± 4.9  |
| Delta change in peak relative VO2 (mL.kg.min-1) | 2.5 ± 3.7  | 3.7 ± 4.0  | 2.8 ± 3.8  | 1.6 ± 3.2  |
| Percent change in peak relative VO2 (%) | 16 ± 28 | 23 ± 28  | 17 ± 28 | 12 ± 27  |
| **Acute coronary syndrome** | **n=196** | **n=27**  | **n=90** | **n=79** |
| Peak relative VO2 (mL.kg.min-1) | 22.0 ± 6.7 | 25.6 ± 6.9  | 24.8 ± 6.2  | 18.9 ± 4.4  |
| Delta change in peak relative VO2 (mL.kg.min-1) | 2.3 ± 3.3  | 4.3 ± 4.3  | 2.6 ± 3.3  | 1.3 ± 2.4  |
| Percent change in peak relative VO2 (%) | 10 ± 14 | 17 ± 16  | 11 ± 13 | 7 ± 13  |
| **Percutaneous coronary intervention** | **n=223** | **n=18**  | **n=105** | **n=100** |
| Peak relative VO2 (mL.kg.min-1) | 21.5 ± 5.9 | 26.4 ± 5.8  | 22.9 ± 6.2  | 19.2 ± 4.5  |
| Delta change in peak relative VO2 (mL.kg.min-1) | 2.5 ± 3.3  | 4.4 ± 3.4 | 2.5 ± 3.6  | 2.0 ± 2.7  |
| Percent change in peak relative VO2 (%) | 13 ± 18 | 18 ± 15  | 12 ± 18 | 12 ± 18  |
| **Heart transplant** | **n=99** | **n=30**  | **n=55** | **n=14** |
| Peak relative VO2 (mL.kg.min-1) | 12.8 ± 4.1 | 12.8 ± 4.2  | 13.1 ± 4.3  | 11.3 ± 2.6  |
| Delta change in peak relative VO2 (mL.kg.min-1) | 5.0 ± 4.1  | 4.9 ± 3.7  | 4.7 ± 4.4  | 6.7 ± 6.2  |
| Percent change in peak relative VO2 (%) | 48 ± 44 | 44 ± 37  | 45 ± 46 | 68 ± 48  |
| **CABG / Valve** | **n=74** | **n=11**  | **n=27** | **n=36** |
| Peak relative VO2 (mL.kg.min-1) | 20.2 ± 6.7 | 24.8 ± 7.6  | 21.3 ± 6.6  | 18.0 ± 5.7  |
| Delta change in peak relative VO2 (mL.kg.min-1) | 1.1 ± 4.3  | 3.0 ± 5.4  | 1.5 ± 4.3  | 0.2 ± 3.9  |
| Percent change in peak relative VO2 (%) | 8 ± 26 | 11 ± 21  | 10 ± 25 | 5 ± 27  |
| **Other** | **n=115** | **n=29**  | **n=46** | **n=40** |
| Peak relative VO2 (mL.kg.min-1) | 18.7 ± 5.8 | 20.3 ± 7.0  | 19.2 ± 5.7  | 17.1 ± 4.4  |
| Delta change in peak relative VO2 (mL.kg.min-1) | 1.7 ± 3.4  | 1.9 ± 3.4  | 2.4 ± 3.8  | 0.8 ± 2.8  |
| Percent change in peak relative VO2 (%) | 12 ± 27 | 14 ± 22  | 14 ± 25 | 8 ± 33  |

Age groups: Younger adults 20-49yrs; Midlife adults 50-64yrs; Older adults ≥65yrs. Continuous data presented as mean ± SD.

Abbreviations: VO2 – oxygen uptake. CABG – coronary artery bypass graft surgery.

‡Breakdown of other category includes, stable angina (4%), heart failure (2%), dyspnea (<1%), sudden cardiac death (<1%), peripheral artery disease (<1%), pericarditis or myocarditis (<1%), or non-specified cardiac event (8%).