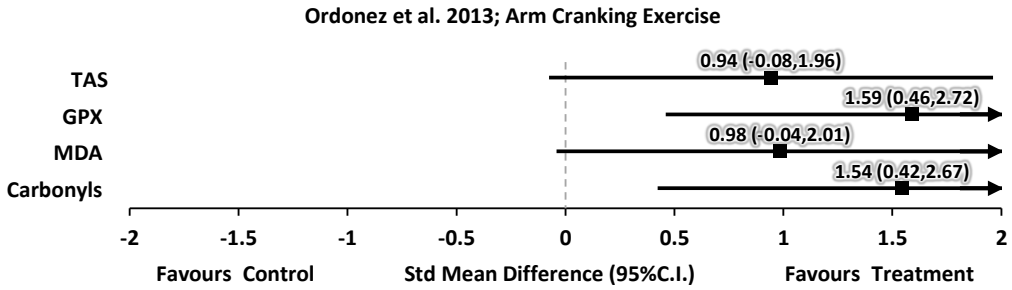
Author, Year; Country Score Research Design Sample Size	Methods	Outcomes
Arm Ergometry		
Ordonez et al. 2013; Italy PEDro=8 RCT Level 1 N=17	**Population:** N=17 male participants with complete SCI at or below the fifth thoracic level (T5); Participants were randomly allocated to the intervention (n=9) or control (n=8) group. *Intervention group:* mean (SD) age: 29.6(3.6) yr; mean (SD) DOI = 54.8(3.4) months. *Control group*: mean (SD) age: 30.2(3.8) yr; mean (SD) DOI = 55.7(3.6) months. **Treatment:** Intervention group performed a 12-week arm-cranking exercise program, 3 sessions/wk, consisting of warming-up (10-15min) followed by a main part in arm-crank (20-30min [increasing 2 min and 30s every 3 wk]) at a moderate work intensity of 50% to 65% of the HR reserve and by a cooling-down period. **Outcome Measures:** Plasmid levels of total antioxidant status, erythrocyte glutathione peroxidase activity malondialdehyde and carbonyl group levels, physical fitness and body composition	1. When compared with baseline results, VO_2peak was significantly increased in the intervention group. 2. Both total antioxidant status and erythrocyte glutathione peroxidase activity were significantly increased at the end of the training program. 3. Plasmatic levels of malondialdehyde and carbonyl groups were significantly reduced following training.
	Effect Sizes: Forest plot of standardized mean differences (SMD ± 95%C.I.) as calculated from pre- and post-intervention data 	
de Groot et al. 2003; The Netherlands PEDro = 7 RCT Level 1 N = 6	**Population:** 4 male, 2 female, C5-L1, AIS A (n = 1), B (n = 1), C (n = 4), age 36 yrs. **Treatment:** Interval training (3-min exercise: 2-min rest), 1hr/d, 3d/wk, 8 wks. Randomized to low intensity (50%–60% HRR) or high intensity (70%–80% HRR). **Outcome Measures:** VO_2peak, maximal power output.	1. Greater changes in VO_2peak in the high-intensity (59%) versus low- intensity group (17%).

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Davis et al. 1991; Canada PEDro = 4 RCT Level 2 N = 24	**Population:** 8 spina bifida, 16 traumatic, age 17–42 yrs. **Treatment:** Random assignment to (a) control or 1 of 3 arm ergometry programs 2 d/wk, 24 wks: (1) high-intensity long duration (40 min at 70% VO_2peak), (2) high-intensity short duration (20 min at 70% VO_2peak), and (3) low-intensity short duration (20 min at 50% VO_2peak) training. **Outcome Measures:** Cardiac output, HR, VO_2peak, power output, stroke volume.	1. Training increased VO_2peak in the 3 arm ergometry groups (~21%). 2. There were increases in submaximal stroke volume and cardiac output in the high-intensity long and the low- intensity long training groups. 3. The low-intensity short duration training and control groups exhibited small non-significant decreases in stroke volume.
Davis et al. 1987; Canada PEDro = 4 RCT Level 2 N = 14	**Population:** Sedentary SCI (*n* = 9 exercise group, *n* = 5 control group), age 20–39 yrs. **Treatment:** Arm ergometry, 50%–70% VO_2peak, 20–40 min/d, 3d/wk, 16 wks. **Outcome Measures:** BP, HR, power output, VO_2peak, resting left ventricular dimensions, cardiac function.	1. Significant improvement in VO_2peak (31%) and HR (-9.5%) with training. 2. During isometric handgrip exercise, decreased rate-pressure product (HR*BP) (20%) and increased stroke volume (12%–16%).
	Effect Sizes: Forest plot of standardized mean differences (SMD ± 95%C.I.) as calculated from pre- and post-intervention data	

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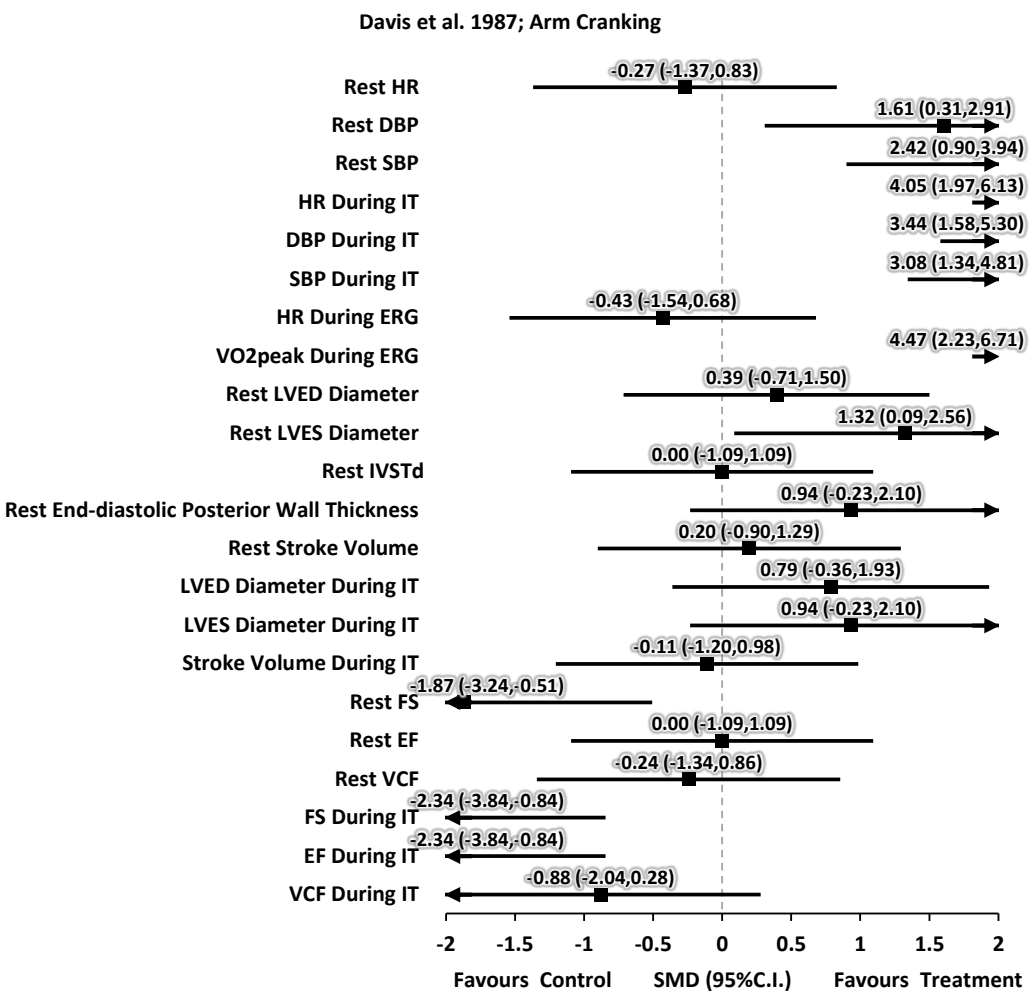
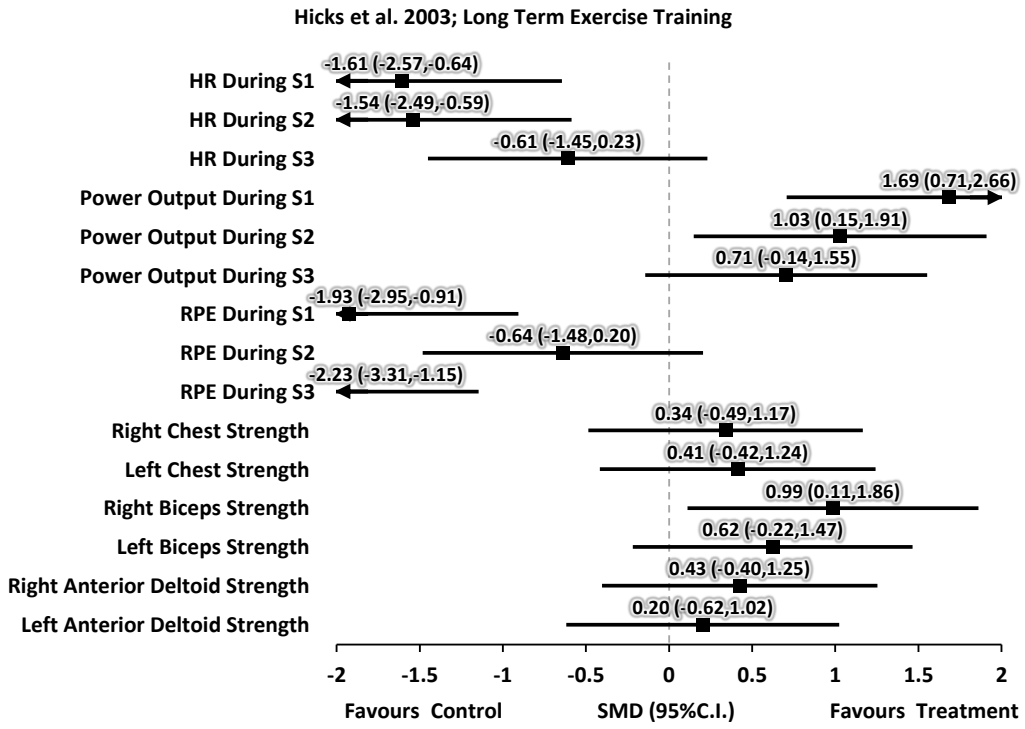
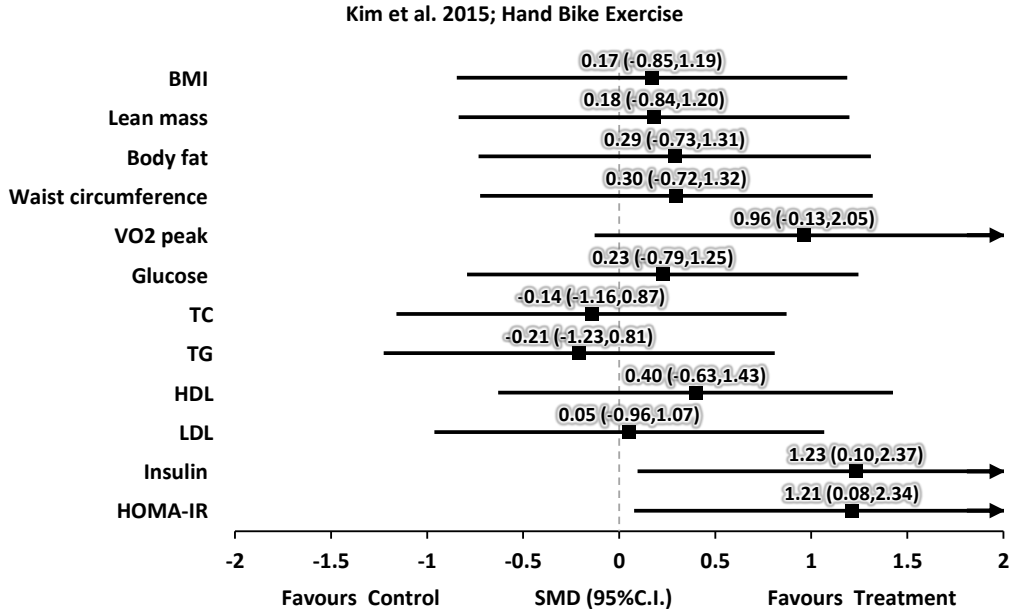
	 **LVES = Left Ventricular End-systolic** **LVED = Left Ventricular End-diastolic** **IVSTd = End-diastolic Intra-ventricular Septal Thickness**	
Hjeltnes and Wallberg-Henriksson, 1998; Norway Prospective controlled trial Level 2 N = 27	**Population:** Exercise group: 10 tetraplegia, C6-8, 7 AIS A & 3 AIS B; Control: 10 paraplegia, T7-11, all AIS A. **Treatment:** Exercise group: standard rehabilitation + arm ergometry, 30min/d, 3d/wk, 12–16 wks; Control: standard rehabilitation. **Outcome Measures:** power output, cardiac function, HR, VO_2, systolic blood pressure, lactate levels, muscular strength, ability to perform activities of daily living.	1. Persons with tetraplegia increased peak workload (45%) with no change in VO_2peak. 2. Peak workload (45.5%) and VO_2peak (27.7) increased significantly in persons with paraplegia. 3. No change in peak HR, systolic BP, submaximal exercise stroke volume, or cardiac output in either SCI group.

Author, Year; Country Score Research Design Sample Size	Methods	Outcomes
Milia et al. 2014 Italy Cohort study Level 2 N=9	**Population:** 9 SCI individuals (2 females, 7 males, mean age of 41) with clinically complete spinal lesions (T4-L1) **Treatment:** One year of exercise training for 3 to 5 hours per week of arm cranking against a workload corresponding to 60% of maximal workload (Wmax). **Outcome measures:** Hemodynamic variables including maximum values of work rate (Wmax), heart rate (HR max), oxygen update (Vo2 max), carbon dioxide production (VCO2 max), respiratory exchange ratio (RER max), pulmonary ventilation (VE max), ventricular filling rate (VFR), end diastolic volume (EDV), mean blood pressure (MBP)	1. After one-year of training, patients reached higher levels in Wmax and VO2 max expressed both in absolute and relative terms. 2. The HR, MBP and EDV responses were significantly increased after one-year training. 3. There were no differences in stroke volume, absolute cardiac output value or VFR absolute values due to training.
Jae et al. 2008; South Korea Case Control Level 3 N = 52 (28 SCI, 24 AB)	**Population**: 28 physically active (trained) competitive wheelchair athletes (below T6). The able-bodied controls (n = 24) were recreationally active age-matched controls. **Outcome Measures**: Measures of arterial structure and function: Common carotid artery intima–media thickness, arterial compliance and b stiffness, and aortic augmentation index (applanation tonometry of radial artery- to capture arterial efficiency)	1. No difference in any of the arterial function indices between groups.
West et al. 2014 Canada Cross-sectional Level 5 N=23	**Population:** 23 elite male paracyclists with SCI (11 with cervical SCI, 12 with thoracic, C3-T8, mean age of 41) at the 2013 Paracycling World Championship **Treatment:** None **Outcome measures**: Heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP)	1. No difference in supine SPB and DBP between the thoracic SCI and cervical SCI group. 2. Seated SBP was lower in cervical SCI than the thoracic SCI group. 3. No difference in maximum heart rate for cervical compared to thoracic SCI groups. The average HR was lower in thoracic SCI compared cervical SCI group. 4. Maximum and average HR also tended to be higher in cervical autonomic incomplete compared to autonomic complete. 5. No difference in HR between thoracic autonomic complete vs. incomplete SCI.
Mixed arm and other exercise		

<table>
<tr><th>Author, Year;
Country
Score
Research Design
Sample Size</th><th>Methods</th><th>Outcomes</th></tr>
<tr><td rowspan="2">Hicks et al. 2003;
Canada
PEDro = 5
RCT
Level 2
N = 23</td><td>Population: 18 tetraplegia and 16 paraplegia, AIS A-D, C4-L1, ages 19–65 yrs.
Treatment: Exercise: 90–120 min/d, 2d/wk, 9 months of arm ergometry (15–30 min, ~70%VO_2max) and circuit resistance exercise; Control group: bimonthly education session.
Outcome Measures: muscular strength, power output, HR, quality of life ratings.</td><td>1. Power output increased by 118% and 45% after training in the tetraplegia and paraplegia groups, respectively.
2. There were progressive increases in strength over the 9 months of training (range 19%–34%).</td></tr>
<tr><td colspan="2">Effect Sizes: Forest plot of standardized mean differences (SMD ± 95%C.I.) as calculated from pre- and post-intervention data
 

ERG = Discontinuous 3-stage Arm Ergometry
S1 = ERG Stage 1; S2 = ERG Stage 2; S3 = ERG Stage 3</td></tr>
<tr><td colspan="3">Wheelchair ergometry</td></tr>
<tr><td>Hooker and Wells 1989;
USA
Prospective controlled trial
Level 2
N = 8</td><td>Population: Low-intensity group n = 6, C5-T7; moderate-intensity group n = 5, C5-T9.
Treatment: Wheelchair ergometry 20 min/d, 3 d/wk, 8 wks: low-intensity (50%–60% max HRR) and moderate-intensity (70%–80% max HRR).
Outcome Measures: HR, power output, blood lactate, VO_2max, Rating of Perceived Exertion (RPE), lipid profiles.</td><td>1. The moderate-intensity group had significantly lower post-training submaximal HR, lactate, and RPE but no changes in oxygen consumption.
2. 70% maximal HRR appears to be the beneficial training threshold.</td></tr>
<tr><td colspan="3">Hand-crank Cycling</td></tr>
</table>

Author, Year; Country Score Research Design Sample Size	Methods	Outcomes
Kim et al. 2015 Korea PEDro=5 RCT Level 2 N = 15	**Population:** 15 participants (9 males, 6 females) with SCI (ASIA-A &B, C5-T11). Mean age was 33 and all participants had SCI for more than 6 months. 8 participants allocated to the hand-bike exercise group, 7 participants to the control group. **Treatment:** Participants exercised with the indoor-hand bike for 60min/day, 3 days/week, for 6 weeks under supervision of an exercise trainer. Participants maintained a heart rate of 70% of their maximum. Exercise intensity was gradually increased on a weekly basis using the Borg rating of perceived exertion (RPE level 5 to 7). The control group continued with usual activities. **Outcome Measures:** Body mass index (BMI), waist circumference, percent body fat, insulin level, homeostasis model assessment of insulin resistance (HOMA-IR) level, upper body muscle strength (using a dynamometer), V02 peak, lipid metabolite indices (including cholesterol, triglycerides, high & low density lipoprotein cholesterol levels.	1. Post-intervention, the exercise group showed significant decrease in BMI, waist circumference, fasting insulin and HOMA-IR levels compared with the control group. 2. The exercise group exhibited significantly lower insulin and HOMA-0R levels, and increase in high density lipoprotein cholesterol after the exercise training period compared with baseline levels. 3. The exercise group also showed significant increases in V02 peak and upper body strength compared with the control group following intervention. 4. No change in glucose, total cholesterol, triglycerides, or low density lipoprotein were observed in the exercise group.
	Effect Sizes: Forest plot of standardized mean differences (SMD ± 95%C.I.) as calculated from pre- and post-intervention data 	
Valent et al. 2008 The Netherlands Cohort Level 2 N = 162	**Population:** Acute SCI participants, level of injury C5 or lower, divided into participants with paraplegia and tetraplegia , and further divided hand–cycling (HC) and non-hand cycling (non-HC) groups according to their rehabilitation protocols; data for 137 participants	1. During clinical rehabilitation, a significantly larger increment in peak power output and VO_2peak was found in participants with paraplegia. 2. On average, peak power output increased

Author, Year; Country Score Research Design Sample Size	Methods	Outcomes
	were available for the clinical rehabilitation period, and 131 for the post-rehabilitation period, 106 were available for both periods, and 162 different participants were tested in total **Treatment:** Hand cycling **Outcome Measures:** Power output; oxygen uptake (VO_2peak); elbow extension strength; measured upon start of active rehabilitation, on discharge, and 1 year after discharge	6.2W more in HC compared to non-HC participants with paraplegia. 3. Compared with baseline, VO_2peak increased by 29% in HC paraplegics, compared to 8% in the non-HC group. 4. Elbow extension strength increased significantly in the HC compared to the non-HC participants with paraplegia. 5. In contrast to the participants with paraplegia, there was no significant difference between HC and non-HC during rehabilitation for participants with tetraplegia. 6. In the post-rehabilitation period, there was no significant difference between HC and non-HC groups.
Nooijen et al. 2015 Netherlands Pre-Post Level 4 N=30	**Population:** 30 SCI individuals, 20 paraplegia, 10 tetraplegia, 12 incomplete lesion, 18 complete lesion **Treatment:** Structured hand cycle interval training program during the last 8 weeks of inpatient rehab. Training was more than 2 times per week at intended intensity of Borg score of 4 to 7 on a 10-point scale. **Outcome Measures:** Peak power output and VO_2peak	1.Peak power output and VO2 peak improved significantly after the training period.
Hubli et al. 2014 Canada Cross-sectional Level 5 N=20	**Population:** 20 individuals with motor-complete chronic SCI (C2-T5, 2-29 years post-injury, AIS-A or B). 10 of these individuals were elite hand-cyclists and 10 were sex matched to sedentary individuals with SCI. **Treatment:** None **Outcome measures:** Aortic Pulse Wave Velocity (PWV), discrete brachial blood pressure, heart rate	1. No differences in systolic blood pressure, diastolic blood pressure, mean arterial pressure, and heart rate when resting supine between athletes and non-athletes. 2. Aortic PWV was significantly lower in athletes compared with non-athletes.

Note: AIS = ASIA Impairment Scale; BP = blood pressure; d = day; hr = hour; HR = heart rate; HRR = heart rate reserve; min = minute; RCT = randomized controlled trial; RPE = rating of perceived exertion; SCI = spinal cord injury; wk = week; yrs = year.