

Supplementary Table S1 Detailed characteristics of included studies selected for meta-analysis and relevant outcomes

Study	Population	Time on dialysis (months)	Sample size	Training variables	Outcome measures	Results
Deligiannis 1999 ³⁷	M and F; Ex 48 ± 12 Con 48 ± 11	Ex 75.6 ± 36.0 Con 74.4 ± 43.2	Ex (n = 30) Con (n = 30)	Ex: non-dialysis days; 10-minute warm-up (bicycling and/or walking); a 50-minute aerobic exercise program (calisthenics, steps, swimming, or ball games); a 20-minute stretching and low-weight resistance program; a 10- minute cool-down period (bicycling and/or walking); 6 months; 3 days/week; 90 min; 60 – 70% HRmax Con: usual care	VO ₂ max	Ex: 41.0 % ↑* Con: no changes
	M; Ex 50.71 ± 21.06 Con 53 ± 19.4	Ex 25.71 ± 7.61 Con 24.86 ± 15.44	Ex (n = 14) Con (n = 14)	Ex: cycling during HD; 8 weeks; 3 days/week; 20 min; 12 - 15 RPE Con: usual care	CRP	Ex: 83.2 % ↓** Con: 1.2 % ↑
Wu 2014 ²⁶	M and F; Ex 45 Con 44	Ex 55.5 ± 37.3 Con 39.8 ± 29.7	Ex (n = 34) Con (n = 35)	Ex: cycling during HD; 12 weeks; 3 days/week; 15 min; 12 – 16 RPE Con: simple stretching exercises; 12 weeks; 3 days/week; 10–15 min	6MWT STS-10	Ex: 8.09 % ↓* Con: 4.77 % ↓ Ex: 5.7 % ↓* Con: 5.0 % ↓
	M and F; Ex 52 ± 14.5 Con 53 ± 16.9	Ex 37 ± 69 Con 21 ± 30	Ex (n = 27) Con (n = 26)	Ex: cycling during HD; 12 weeks; 3 days/week; 45 min; 13 RPE Con: walking program at home	peakVO ₂	Ex: after 12 weeks: 9.89 % ↑ after 24 weeks: no change Con: after 12 weeks: 3.31 % ↓

						6MWT	after 24 weeks: 1.66 % ↑ Ex: after 12 weeks: 6.58 % ↑ after 24 weeks: 3.96 % ↑ Con: after 12 weeks: 1.67 % ↑ after 24 weeks: 0.05 % ↓
Groussard 2015 ²⁸	M and F; Ex 66.5 ± 4.6 Con 68.4 ± 3.7	Ex 36.6 ± 8.2 Con 41.2 ± 8.1	Ex (n = 8) Con (n = 10)	Ex: cycling during HD; 3 months; 3 days/week; 30 min; 55%–60% peak power Con: usual care	6MWT peakVO ₂	Ex: 23.15 % ↑** Con: 7.98 % ↑ Ex: 2.72 % ↓ Con: 14.18 % ↑	
Hristea 2016 ⁶¹	M and F; Ex 68.5 ± 13.97 Con 70.8 ± 15.18	Ex 139 Con 96	Ex (n = 10) Con (n = 11)	Ex: cycling during HD; 6 months; 3 days/week; 30 min; 3 RPE (modified Borg scale) Con: usual care	6MWT CRP	Ex: 21.8 % ↑** Con: 18.8 % ↓ Ex: 30.6 % ↓** Con: 19.8 % ↓	
Liao 2016 ²⁹	M and F; Ex 62 ± 8 Con 62 ± 9	Ex 71 ± 46 Con 83 ± 71	Ex (n = 20) Con (n = 20)	Ex: cycling during HD; 3 months; 3 days/week; 20 min; 13-14 RPE Con: usual care	CRP 6MWT	Ex: 37.6 % ↓* Con: 0.81 % ↓ Ex: 11.1 % ↑* Con: 1.1 % ↓	
Cheema 2007 ³⁰	M and F; Ex 60.0 ± 15.3 Con 65.0 ± 12.9	Ex 39.6 Con 19.2	Ex (n = 24) Con (n = 25)	Ex: progressive resistance training; two sets of eight repetitions of 10 exercises; during HD; 12 weeks; 3 days/week; 45 min; 15 – 17 RPE Con: usual care	6MWT CRP	Ex: 3.36 % ↑ Con: 0.74 % ↓ Ex: 10.26 % ↓* Con: 33.33 % ↑*	
Kirkman 2014 ³¹	M and F; Ex 48 ± 18 Con 58 ± 15	Ex 46 ± 54 Con 66 ± 47	Ex (n = 9) Con (n = 10)	Ex: progressive resistance training during HD; 12 weeks; 3 days/week;	6MWT	Ex: 7.33 % ↑ Con: 13.04 % ↑	

80 % of their
predicted 1RM

Con: stretching
during HD

Kouidi 1997 ⁴⁸	M and F; Ex 49.6 ± 12.1 Con 52.8 ± 10.2	Ex 70.8 ± 58.8 Con 74.4 ± 64.8	Ex (n = 20) Con (n = 11)	Ex: stationary cycling, walking or jogging, calisthenics, aerobics, swimming and/or game sports (basketball, football); non-dialysis days; 6 months; 3 days/week; 90 min; 50-60 % VO ₂ max Con: usual care	VO ₂ max	Ex: 38.09 % ↑* Con: 1.24 % ↓
Painter 2002 ⁶²	M and F; Ex 55.9 ± 15.15 Con 52.8 ± 16.8	Ex 33.7 ± 35.6 Con 40.2 ± 62.4		Ex: cycling during HD; 5 months; 3 days/week; 30 min; 12 – 14 RPE Con: usual care	peakVO ₂	Ex: 13.3 % ↑* Con: 0.5 % ↑
DePaul 2002 ³²	M and F; Ex 55 ± 16 Con 54 ± 14	Ex 50.4 ± 57.6 Con 55.2 ± 54.0	Ex (n = 20) Con (n = 18)	Ex: cycling during HD + strength training for hamstrings and quadriceps muscle groups before or after HD; 12 weeks; 3 days/week; 30 min; 13 RPE Con: non-progressive, non-resisted, low- intensity range-of- motion exercises of the lower extremities and free upper extremity during HD; 12 weeks; 3 days/week; 30 min	6MWT	Ex: 0.87 % ↑ Con: 0.94 % ↑
Konstantinid ou 2002 ⁴⁴	M and F; group A 46.4 ± 13.9 group B 48.3 ± 12.1 group C 51.4 ± 12.5 group D 50.2 ± 7.9	group A 78 ± 62 group B 72 ± 66 group C 62 ± 37 group D 79 ± 86	group A (n = 16) group B (n = 10) group C (n = 10) group D (n = 12)	group A: guided exercise program; non-dialysis days; 6 months; 3 days/week; 60 min; 60–70% HRmax group B: during HD	peakVO ₂	group A: 42.77 % ↑* group B: 23.93 % ↑* group C: 17.28 % ↑* group D: 3.07 % ↓

30 min cycling + 30 min exercises for strength and flexibility
6 months;
3 days/week;
70% HRmax

group C:
home-based program of 30 min cycling + simple flexibility and muscular extension exercises
6 months;
5 days/week;
50–60% HRmax

group D:
usual care

van Vilsteren 2005 ³⁴	M and F; Ex 52 ± 15 Con 58 ± 16	Ex 38.6 ± 48.9 Con 46.8 ± 52.9	Ex (n = 53) Con (n = 43)	Ex: pre-dialysis strength training programme + cycling (during HD) and exercise counselling 12 weeks; 2-3 days/week mean duration: strength training: 16.78 min cycling: 49.86 min 12 – 16 RPE Con: usual care	STS-10 peakVO ₂	Ex: 22.36 % ↓* Con: 0.25 % ↓ Ex: 10.14 % ↑ Con: 0.46 % ↑
Kopple 2007 ⁶³	M and F; group 1 45.9 ± 4.1 group 2 46.0 ± 2.7 group 3 42.7 ± 3.8 group 4 41.3 ± 3.3	group 1 45.9 ± 14.1 group 2 51.9 ± 12.4 group 3 38.3 ± 5.8 group 4 51.4 ± 21.0	group 1 (n = 10) group 2 (n = 15) group 3 (n = 12) group 4 (n = 14)	Group 1: cycling during HD; 5 months: 3 days/week; 30 min; 50% peakVO ₂ Group 2: strength training; before HD; 5 months: 3 days/week; 75% of the 5-RM Group 3: endurance + strength training; a combination of approximately one half of the group 1 work effort and also one half of the group 2 work effort; before and during HD; 5 months: 3 days/week Group 4: usual care	CRP	group 1: 44.44 % ↓ group 2: 20.00 % ↑ group 3: 26.09 % ↑ group 4: 33.33 % ↑

Kouidi 2009 ³⁸	M and F; Ex 54.6 ± 8.9 Con 53.2 ± 6.1	Ex 75.6 ± 44.4 Con 74.4 ± 46.8	Ex (n = 30) Con (n = 29)	Ex: cycling + strength training during HD; 10 months; 3 days/week; 90 min; 13 RPE Con: usual care	peakVO ₂	Ex: 30.49 % ↑** Con: 1.19 % ↓
Koh 2010 ⁵²	M and F; group 1 52.3 ± 10.9 group 2 52.1 ± 13.6 group 3 51.3 ± 14.4	group 1 32.1 ± 26.7 group 2 37.0 ± 31.1 group 3 25.8 ± 22.2	group 1 (n = 15) group 2 (n = 15) group 3 (n = 16)	group 1: cycling during HD; 6 months; 3 days/week; 30 min; 13-14 RPE group 2: walking at home; 6 months; 3 days/week; 30 min; 13-14 RPE group 3: usual care	6MWT	group 1: 13.61 % ↑ group 2: 11.04 % ↑ group 3: 4.87 % ↑
Afshar 2010 ⁶⁴	M; group 1 50.7 ± 21.06 group 2 51 ± 16.4 group 3 53 ± 19.4	group 1 25.71 ± 7.61 group 2 24.86 ± 18.69 group 3 24.86 ± 15.44	group 1 (n = 7) group 2 (n = 7) group 3 (n = 7)	group 1: cycling during HD; 8 weeks; 3 days/week; 30 min; 12-16 RPE group 2: resistance training (ankle weights for knee extension, hip abduction, and flexion); 8 weeks; 3 days/week; 30 min; 15-17 RPE group 3: usual care	CRP	group 1: 83.85 % ↓** group 2: 67.89 % ↓* group 3: 1.47 % ↑
Ouzouni 2009 ³⁹	M and F; Ex 47.4 ± 15.7 Con 50.5 ± 11.7	Ex 92.4 ± 84 Con 103.2 ± 72	Ex (n = 19) Con (n = 14)	Ex: cycling + strength training during HD; 10 months; 3 days/week; 60-90 min 13-14 RPE Con: usual care	peakVO ₂	Ex: 21.05 % ↑* Con: 0.99 % ↓
Orcy 2012 ⁶⁵	M and F; group 1 56.9 ± 14.8 group 2 55.8 ± 18.3	group 1 22.5 group 2 23	group 1 (n = 13) group 2 (n = 13)	group 1: 20 min of cycling during HD; 10 min of resistance training during HD; 10 weeks; 3 days/week; 13-14 RPE	6MWT	group 1: 9.01 % ↑* group 2: 4.48 % ↓

				group 2: 30 min of resistance training during HD; 10 weeks; 3 days/week; 13-14 RPE		
Tao 2015 ⁴¹	M and F; Ex 53.02 ± 11.62 Con 56.68 ± 9.67	Ex 83.46 ± 61.37 Con 84.70 ± 70.55	Ex (n = 57) Con (n = 56)	Ex: flexibility and strength exercise before HD; 6 weeks; 1 day/week; 20 min; RPE 12-13 + nurse case management on home exercise; 1 day/week; 20 min Con: flexibility and strength exercise before HD; 6 weeks; 1 day/week; 20 min; RPE 12-13	STS-10	Ex: 21.03 % ↓** Con: 16.24 % ↓*
Carmack 1995 ⁶⁶	M and F; All subjects 44.09	All subjects 29.52	Ex (n = 10) Con (n = 11)	Ex: cycling during HD; 10 weeks; 3 days/week; 25 min Con: usual care	peakVO ₂	Ex: 34.58 % ↑* Con: 9.0 % ↑
Deligiannis 1999 ³⁷	M and F; group 1 46.4 ± 13.9 group 2 51.4 ± 12.5 group 3 50.2 ± 1.9	group 1 78±62 group 2 62±37 group 3 79±86	group 1 (n = 16) group 2 (n = 10) group 3 (n = 12)	group 1: 10-min warm-up on a cycle ergometer or treadmill, a 50-min intermittent aerobic exercise program, including calisthenics, steps and flexibility exercises and a 10-min cooldown period; non-dialysis days; 6 months; 3 days/week; 90 min; 60-70% HRmax group 2: cycling at home; 6 months; 5 days/week; 30 min; 50-60% HRmax + simple flexibility and muscular extension exercises	VO ₂ max	group 1: 42.8 % ↑** group 2: 17.3 % ↑* group 3: 3.07 % ↓

group 3:
usual care

Tsuyuki 2003 ⁶⁷	M and F; Ex 40.1 ± 11.9 Con 39.7 ± 10.7	Ex 25.2 Con 32.4	Ex (n = 17) Con (n = 12)	Ex: combination training of stationary cycling, walking and jogging; non-dialysis days; 20 weeks; 2-3 days/week; 30 min; 50-60% of the peak heart rate Con: usual care	peakVO ₂	Ex: 25.58 % ↑** Con: 2.25 % ↓
Segura-Ortí 2009 ⁴⁶	M and F; group 1 53.5 ± 18.0 group 2 60.1 ± 16.9	group 1 37.3 ± 34.9 group 2 53.7 ± 42.0	group 1 (n = 17) group 2 (n = 18)	group 1: during HD - four progressive isotonic and isometric resistance exercises that targeted major muscle groups of the lower extremities; 6 months; 3 days/week; 25 min; 12-14 RPE group 2: cycling during HD; 6 months; 3 days/week; 25 min; 11 RPE	STS-10 6MWT	group 1: 22.31 % ↓** group 2: 6.37 % ↓ group 1: 11.21 % ↑** group 2: 8.95 % ↑
Johansen 2006 ⁶⁸	M and F; Ex 54.4 ± 13.6 Con 56.8 ± 13.8	Ex 33.0 Con 25.5	Ex (n = 20) Con (n = 20)	Ex: resistance exercise using ankle weights during HD: 60% of 3RM for two sets of 10 repetitions; increased to three sets as tolerated; three sets with correct technique – increase weight; knee extension, hip flexion and abduction, ankle dorsiflexion and plantarflexion; 12 weeks; 3 days/week Con: usual care	STS-10	Ex: 16.11 % ↓ Con: 0.66 % ↓
Daniilidis 2004 ⁴⁰	M and F; Ex 46.7 ± 13.8 Con 53.7 ± 7.1	Ex 78 ± 62.4 Con 72 ± 81.8	Ex (n = 18) Con (n = 14)	Ex: supervised interval aerobic exercise: steps, treadmill, gymnastics, swimming and ball games; non-dialysis days;	peakVO ₂	Ex: 42.77 % ↑* Con: 2.45 % ↓

6 months;
3 days/week;
60 min;
75%-85% of the
estimated peak heart
rate

Con: usual care

Pellizzaro 2013 ⁴⁵	M and F; Ex 48.9±10.1 Con 51.9±11.6	Ex 54 Con 54	Ex (n = 14) Con (n = 14)	Ex: 3 sets of 15 repetitions of knee extension; 10 weeks; 3 days/week; 50% of 1RM Con: usual care	6MWT	Ex: 6.84 % ↑* Con: 0.07 % ↑
Dobsak 2012 ⁶⁹	M and F; Ex 58.2 ± 7.2 Con 60.1 ± 8.2	Ex 49.2 ± 25.2 Con 49.2 ± 27.6	Ex (n = 11) Con (n = 10)	Ex: cycling during HD; 20 weeks; 3 days/week; 20-40 min; 60% peak workload Con: usual care	6MWT	Ex: 15.02 % ↑** Con: 3.32 % ↓
Reboredo 2015 ³⁶	M and F; Ex 50.7 ± 10.7 Con 42.2 ± 13.0	Ex 39.6 ± 40.8 Con 57.6 ± 52.8	Ex (n = 12) Con (n = 12)	Ex: lower-limb stretching exercises (10 min), low- intensity cycling (5 min), moderate- intensity cycling (35 min) and cool down (3 min) during HD; 12 weeks; 3 days/week; 43 min; 4-6 RPE Con: usual care	peakVO ₂	Ex: 12.4 % ↑* Con: 9.2 % ↓
Frih 2017 ⁴²	M; Ex 64.2 ± 3.4 Con 65.2 ± 3.1	Ex 72.7 ± 12.7 Con 73.6 ± 13.4	Ex (n = 21) Con (n = 20)	Ex: resistance training + aerobic training (cycling + walking) 16 weeks; 4 days/week; 40 min; 5-6 RPE (Borg 10 grade scale); 60% of 1RM Con: usual care	6MWT STS-10	Ex: 15.94 % ↑* Con: 1.56 % ↓ Ex: 16.2 % ↓* Con: 0.95 % ↑
Valenzuela 2018 ⁴³	M and F; Ex 68 ± 13 Con 68 ± 11	Ex 84 ± 60 Con 60 ± 48	Ex (n = 27) Con (n = 40)	Ex: resistance exercises and cycling during HD; 14 weeks; 3 days/week; 50 min; RPE 13 Con: usual care	6MWT STS-10	Ex: 11.05 % ↑** Con: 3.23 % ↓ Ex: 22 % ↓** Con: 6 % ↑

				Con: usual care	
Abreu 2017 ³³	M and F; All subjects 46.4 ± 14.6	ND	Ex (n = 25) Con (n = 19)	Ex: resistance training during HD; 4 lower limb exercises with ankle cuffs and elastic band resistance; 3 sets of 10 rep.; 12 weeks; 3 days/week; 30 min; 60% of 1RM	CRP Ex: 24.68 % ↓ Con: 1.64 % ↓
				Con: usual care	

Abbreviations: Ex experimental group, Con control group, RM repetition _{maximum}, CRP C-reactive protein, STS-10 ten repetition sit-to-stand test, 6MWT six-minute walk test, HD hemodialysis, M male, F female, RPE rate of perceived exertion, HR heart rate, n number of subjects, SD standard deviation, ND no data. *, p < 0.05 indicates significant within-group difference. **, p < 0.01 indicates significant within-group difference.