

Supplementary online material

Aerobic fitness in children with cerebral palsy compared with typically developing peers: a systematic review and meta-analysis.

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S1 Table: Search terms and results

Search completed on November 15, 2023.

Databases		
	Before de-duplicating	After de-duplicating
PubMed (MEDLINE), APA PsycArticles, APA PsycInfo, CINAHL, SPORTDiscus (EBSCO)		
Total	480	398

PubMed (MEDLINE)

#	Searches	Results
1	"oxygen consumption"[MeSH Terms] OR "oxygen consumption"[Title/Abstract] OR "vo2"[Title/Abstract] OR "aerobic capacity"[Title/Abstract] OR "cardiorespiratory fitness"[Title/Abstract] OR "exercise capacity"[Title/Abstract] OR "oxygen uptake"[Title/Abstract]	164,197
2	"cerebral palsy"[MeSH Terms] OR "cerebral palsy"[Title/Abstract]	32,483
3	"child"[MeSH Terms] OR "adolescent"[MeSH Terms] OR "minors"[MeSH Terms] OR "children"[Title/Abstract] OR "kids"[Title/Abstract] OR "youth"[Title/Abstract] OR "minors"[Title/Abstract] OR "juveniles"[Title/Abstract] OR "boys"[Title/Abstract] OR "girls"[Title/Abstract] OR "preadolescents"[Title/Abstract] OR "teen*"[Title/Abstract] OR "youngsters"[Title/Abstract] OR "adolescents"[Title/Abstract]	3,790,169
4	#1 AND #2 AND #3	177

PsycArticles, PsycInfo, CINAHL & SPORTDiscus (EBCOST)

#	Searches	Results
1	TX aerobic capacity OR TX cardiorespiratory fitness OR TX exercise capacity OR TX oxygen consumption OR TX vo2	67,966
2	TX cerebral palsy	33,810
3	TX children OR TX adolescents OR TX minors OR TX kids OR TX youth OR TX boys OR TX girls OR TX preadolescent OR TX teenagers OR TX teens OR TX youngsters	3,160,994
4	#1 AND #2 AND #3	303

S2 Table: Main characteristics and quality assessment of the 36 included studies, alphabetically ordered by first author per maximal exercise test used.

Study	Study country	Data used more than once? [‡]	Data used for overall pooling in meta-analysis?	Children with TD peers		Quality assessment (i.e. Risk of Biased VO _{2peak} measurement)			
				CP at inclusion (n)	at inclusion (n)	Reported how VO _{2peak} was defined?	Prior stated additional peak criteria (e.g. HR, RER, exertion)?	Reporting the number of children who successfully completed the maximal exercise test?	
Bicycle Ergometer									
1	Balemans et al. (2013)	Netherlands	Yes	Yes	70	31	Yes	Yes	Yes
2	Balemans et al. (2015)	Netherlands	Yes	No	46		Yes	Yes	Yes
3	Balemans et al. (2015)	Netherlands	Yes	No	46		Yes	Yes	Yes
4	Balemans et al. (2017)	Netherlands	No	Yes	37	20	Yes	Yes	Yes
5	Brehm et al. (2014)	Netherlands	Yes	No	21		Yes	Yes	Yes
6	Depiazzi et al. (2021)	Australia	No	Yes	12		Yes	Yes	Yes
7	Jung et al. (2015)	Republic of Korea	No	Yes	4	2	Yes	No	Yes
8	Leunkeu et al. (2005)	France	No	No	9	10	Yes	Yes	No
9	Leunkeu et al. (2009)	France	No	No	8	8	Yes	Yes	No
10	Nsenga Leunkeu et al. (2012)	France	Yes	No	28		Yes	No	Yes
11	Nsenga et al.(2013)	France	Yes	Yes	24	12	Yes	No	Yes
12	Lundberg (1978)	Sweden	No	Yes	9	9	No	Yes	Yes
13	Lundberg (1984)	Sweden	No	No	26	12	No	No	Yes
14	Van Wely et al. (2014)	Netherlands	Yes	No	49		No	No	Yes
15	Sansare et al. (2021)	United States of America	No	Yes	15		Yes	No	Yes
Treadmill exercise test									
16	Dahlbäck and Norlin (1985)	Sweden	No	No	6		No	No	Yes
17	Garcia et al. (2016)	Spain	No	Yes	40	40	Yes	Yes	Yes
18	Hoofwijk et al. (1995)	Canada and United Kingdom	Yes	Yes	9	9	Yes	Yes	Yes
19	Kim et al. (2021)	Republic of Korea	Yes	Yes	40		No	No	Yes
20	Lauglo et al. (2016)	Norway	No	Yes	20		Yes	Yes	Yes
21	Lee et al. (2023)	Republic of Korea	Yes	No	39		No	No	Yes
22	Maltais et al. (2005)	Canada	No	Yes	11		Yes	Yes	Yes
23	Massin and Allington (1999)	Belgium	No	No	15		No	No	Yes
24	Park et al. (2021)	Republic of Korea	Yes	No	26		No	No	Yes
25	Unnithan et al.(1996)	Canada	Yes	No	9	9	Yes	No	Yes
26	Verschuren and Takken (2010)	Netherlands	Yes	Yes	24		No	Yes	Yes
27	Suk and Kwon (2022)	Republic of Korea	Yes	No	46		No	No	Yes

Arm crank ergometer test									
28	Klimek-Piskorz and Piskorz (1997)	Poland	No	Yes	14		No	No	Yes
29	Klimek-Piskorz et al.(2005)	Poland	No	Yes	10	10	Yes	Yes	Yes
30	Klimek-Piskorz (2006)	Poland	No	Yes	8		Yes	No	Yes
31	Unnithan et al.(2007)	Greece	No	Yes	14		No	Yes	Yes
Shuttle Run Test									
32	Dallmeijer and Brehm (2011)	Netherlands	No	Yes	8	10	Yes	Yes	Yes
33	Zwinkels et al. (2017)	Netherlands	Yes	Partly	15		No	Yes	Yes
Two types of exercise tests									
34	Verschuren et al.(2006)	Netherlands	Yes	Partly	25		No	Yes	Yes
35	Piskorz and Klimek-Piskorz (1998)	Poland	No	Yes	15		Yes	No	Yes
36	Verschuren et al. (2013)	Netherlands	No	Yes	23		Yes	Yes	Yes

Abbreviations: CP = cerebral palsy; n = number; VO_{2peak} = peak oxygen uptake; HR = heart rate; RER = respiratory exchange ratio.

S3 Table: VO_{2peak} and physiological characteristics of the 36 included studies

Study	Type of maximal exercise test	Children with CP			TD peers		
		VO _{2peak} , mL/kg/min (mean ± SD) [range]	HR _{max} , bpm (mean ± SD) [range]	RER (mean ± SD)	VO _{2peak} , mL/kg/min (mean ± SD)	HR _{max} , bpm (mean ± SD)	RER (mean ± SD)
Balemans et al. (2013)	Cycle ergometer test	GMFCS I (n=35): 35.5 ± 7.20* GMFCS II (n=20): 33.9 ± 7.16* GMFCS III (n=8): 29.3 ± 7.07*	GMFCS I: 192 ± 1.7 GMFCS II (n=23): 187 ± 2.1 GMFCS III: 187 ± 3.6	GMFCS I (n=32): 1.11 ± 0.02 GMFCS II (n=17): 1.14 ± 0.02 GMFCS III (n=7): 1.13 ± 0.04	41.0 ± 7.24* (n=31)	194 ± 1.8	NR
Balemans et al. (2015)	Cycle ergometer test	Overall (n=38): 31.4 ± 6.2 Unilateral spastic CP (n=20): 33.5 ± 5.4 Bilateral spastic CP (n=18): 29.0 ± 6.3	NR	NR		No TD peers group	
Balemans et al. (2015)	Cycle ergometer test	Overall (n=38): 31.4 ± 6.2 Unilateral spastic CP (n=20): 33.5 ± 5.4 Bilateral spastic CP (n=18): 29.0 ± 6.3	NR	NR		No TD peers group	
Balemans et al. (2017)	Cycle ergometer test	GMFCS I (n=13): 40.0 ± 8.6 GMFCS II (n=17): 36.4 ± 6.8 GMFCS III (n=7): 31.5 ± 7.7	GMFCS I: 190 ± 12 GMFCS II: 190 ± 8 GMFCS III: 181 ± 11	GMFCS I: 1.09 ± 0.14 GMFCS II: 1.12 ± 0.16 GMFCS III: 1.07 ± 0.07	50.2 ± 8.5 (n=20)	193 ± 9	1.06 ± 0.05
Brehm et al. (2014)	Cycle ergometer test	39.8 ± 7.7 (n=16)	190 ± 11	1.05 ± 0.14		No TD peers group	
Dahlbäck and Norlin (1985)	Treadmill exercise test	NR	152 ± 8	0.92 ± 0.06		No TD peers group	
Dallmeijer and Brehm (2011)	Shuttle run test	37.2 ± 2.2 (n=7)	197 ± 8 (n=6)	1.02 ± 0.09 (n=7)	45.0 ± 5.3 (n=10)	200 ± 7 (n=10)	0.96 ± 0.07 (n=10)
Depiazzi et al. (2021)	Cycle ergometer test	Control group (n=6): 31.45 ± 4.55 Intervention group (n=6): 32.40 ± 9.35	Control group: 176 ± 16.8 Intervention group: 175 ± 11.2	1.18 (range 1.03 ± 1.24) (n=12)		No TD peers group	
Garcia et al. (2016)	Treadmill exercise test	28.7 ± 7.0 (n=40)	NR	NR	40.2 ± 9.0 (n=40)	NR	NR
Hoofwijk et al. (1995)	Treadmill exercise test	Overall (n=9): 32.7 ± 4.8 Boys (n=7): 32.6 ± 5.4 Girls (n=2): 33.3 ± 2.3	Overall: 189 ± 17 Boys: 191 ± 19 Girls: 183 ± 4	Overall: 1.14 ± 0.06 Boys: 1.14 ± 0.06 Girls: 1.13 ± 0.08	Overall (n=9): 45.20 ± 8.4 Boys (n=7): 48.6 ± 5.7	Overall: 197 ± 9 Boys: 195 ± 9 Girls: 205 ± 4	Overall: 1.15 ± 0.06 Boys: 1.16 ± 0.05 Girls: 1.13 ± 0.08

Jung et al. (2015)	Cycle ergometer test	37.6 ± 16.35* (n=4)	138 ± 8.07	1.06 ± 0.18	Girls (n=2): 33.2 ± 1.6 39.7 ± 23.76* (n=2)	120 ± 15	0.90 ± 0.08
Kim et al. (2021)	Treadmill exercise test	Overall (n=37): 25.44 ± 3.73 GMFCS I (n=21): 26.20 ± 4.13 GMFCS II (n=16): 24.42 ± 2.94	Overall: 167.08 ± 12.75 GMFCS I: 165.38 ± 15.07 GMFCS II: 169.31 ± 8.83	Overall: 0.98 ± 0.05 GMFCS I: 0.97 ± 0.05 GMFCS II: 0.99 ± 0.04		No TD peers group	
Klimek-Piskorz and Piskorz (1997)	Arm crank ergometer test	35.0 ± 6.1 (n=14)	182 ± 15	NR		No TD peers group	
Klimek-Piskorz et al. (2005)	Arm crank ergometer test	45.0 ± 5.0 (n=10)	180.1 ± 7.0	NR	46.2 ± 5.4 (n=10)	199.0 ± 6.5	NR
Klimek-Piskorz (2006)	Cycle ergometer test	26.4 ± 3.3 (n=8)	177 ± 12	NR		No TD peers group	
Lauglo et al. (2016)#	Treadmill exercise test	39.9 (30.5-45.0) (n=8)	193 (186-199)	NR		No TD peers group	
Lee et al. (2023)	Treadmill exercise test	25.50 ± 3.58 (n=39)	167.41 ± 13.83	0.98 ± 0.05		No TD peers group	
Leunkeu et al. (2005)	Cycle ergometer test	20.6 (n=9)	NR	NR		No average data available	
Leunkeu et al. (2009)	Cycle ergometer test	31.27 ± 12.04#	No average data available	NR		No average data available	
Nsenga Leunkeu et al. (2012)	Cycle ergometer test	32.3 ± 6.3 (n=28)	148.4 ± 25.1	NR		No average data available	
Nsenga et al. (2013)	Cycle ergometer test	Control group (n=10): 34.9 ± 6.4 Intervention group (n=10): 35.6 ± 5.6	Control group: 181.1 ± 10.0 Intervention group: 181.1 ± 10.2	NR	43.0 ± 4.4 (n=10)	197.2 ± 18.0	NR
Lundberg (1978)	Cycle ergometer test	Boys (n=5): 48 ± 10 Girls (n=4): 37 ± 6	Boys: 196 ± 5 Girls: 195 ± 11	Boys: 0.90 ± 0.09 Girls: 0.87 ± 0.04	Boys (n=6): 54 ± 8 Girls (n=3): 45 ± 10	Boys: 195 ± 6 Girls: 201 ± 8	Boys: 0.96 ± 0.04 Girls: 1.06 ± 0.10
Lundberg (1984)	Cycle ergometer test	Diplegic boys (n=12): y = 20.9 + 2.00*age Diplegic girls (n=7): y = 31.8 + 0.54*age	Diplegic total (n = 19): y=203.7 – 0.56x	Diplegic total (n = 19): 0.90 ± 0.04 Dyskinetic total (n = 4): 0.96 ± 0.03 Hemiplegic total (n = 3): 0.99 ± 0.00	Boys (n=7): y = 43.1 + 1.28*age Girls (n=5): y = 47.0 + 0.10*age	Controls total (n = 12): y = 202.1 – 0.55x	Controls total (n = 12): 1.02 ± 0.02
Maltais et al. (2005)	Treadmill exercise test	34.0 ± 9.2 (n=11)	189 ± 12	1.05 ± 0.11		No TD peers group	
Massin and Allington (1999)	Treadmill exercise test	No average data available	NR	NR		No TD peers group	

Park et al. (2021)	Treadmill exercise test	Control group (n=13): 26.62 ± 5.10 Intervention group (n=13): 25.25 ± 2.69	Control group: 164.23 ± 14.87 Intervention group: 165.62 ± 13.22	NR			No TD peers group
Piskorz and Klimek-Piskorz (1998)	Arm crank ergometer test	35.8 ± 7.7 (n=15)	177 ± 11	NR			No TD peers group
Sansare et al. (2021)	Cycle ergometer test	45.0 ± 5.7 (n=15)	179 ± 10	NR			No TD peers group
	Cycle ergometer test	Control group (n=11): 24.9 [95%CI: 20-29.9] Intervention group 1 (n=14): 24.9 [95%CI: 18.4-31.4] Intervention group 2 (n=11): 24.5 [95%CI: 17.7-31.4]	Control group: 49 [95%CI: 37-61] Intervention group 1: 61 [95%CI: 45-77] Intervention group 2: 47 [95%CI: 30-64]	NR			No TD peers group
Suk and Kwon (2022)	Treadmill exercise test	Control group (n=23): 26.31 Intervention group (n=23): 24.75	Control group: 168.62 Intervention group: 169.10	Control group: 0.98 Intervention group: 0.98			No TD peers group
Unnithan et al. (1996)	Treadmill exercise test	32.7 ± 4.8 (n=9)	NR	NR	45.2 ± 8.4 (n=9)	NR	NR
Unnithan et al. (2007)	Arm crank ergometer test	Control group (n=6): 17.9 ± 4.39 Intervention group (n=7): 17.5 ± 4.45	Control group: 152.0 ± 12.5 Intervention group: 146.0 ± 20.4	Control group: 1.07 ± 0.13 Intervention group: 1.02 ± 0.11			No TD peers group
Van Wely et al. (2014)	Cycle ergometer test	Control group (n=20): 33 ± 6.6 Intervention group (n=19): 30 ± 5.3	NR	NR			No TD peers group
Verschuren et al. (2006)	Shuttle run test	NR	GMFCS I: 200.6 ± 6.7 GMFCS II: 199.4 ± 6.8	GMFCS I: 1.1 ± 0.1 GMFCS II: 1.0 ± 0.1			No TD peers group
	Treadmill exercise test	n=24 GMFCS I: 43.80 ± 6.50 GMFCS II: 39.90 ± 9.70	GMFCS I: 192.9 ± 6.2 GMFCS II: 193.1 ± 6.1	GMFCS I: 0.9 ± 0.9 GMFCS II: 1.0 ± 0.8			No TD peers group
Verschuren and Takken (2010)	Treadmill exercise test	Overall (n=24): 42.0 ± 8.2 Boys (n=16): 44.7 ± 7.1 Girls (n=8): 36.4 ± 7.6	193.1 ± 6.2	1.0 ± 0.1			External reference data of 336 TD peers were used. These TD peers outcomes were not included in our review
Verschuren et al. (2013)	Arm crank ergometer test	25.3 ± 5.7 (n=23)	160.5 ± 24.5	1.0 ± 0.1			No TD peers group
	Shuttle ride test	26.0 ± 5.0 (n=23)	171.0 ± 23.2	1.1 ± 0.2			No TD peers group

Zwinkels et al. (2017) 2004- matched sample	Shuttle run test	Overall (n=25): 40.9 ± 8.4 GMFCS I (n=15): 41.9 ± 6.2 GMFCS II (n=10): 39.7 ± 10.8	198 ± 5	1.05 ± 0.11	No TD peers group
Zwinkels et al. (2017) 2014- matched sample	Shuttle run test	Overall (n=25): 37.5 ± 10.4 GMFCS I (n=15): 40.2 ± 12.6 GMFCS II (n=10): 34.3 ± 5.0	183 ± 18	1.07 ± 0.10	No TD peers group

If reported, the number of participants is noted who completed the test and were included in the analysis.

** Data was reported as median (standard error) and is for the purposes of this study converted into median ± SD values.*

Data is reported as median (interquartile range).

‡Data is reported as ml/kg/lean body mass.

Abbreviations: bpm, beats per minute; CP, cerebral palsy; GMFCS, Gross Motor Function Classification System; n, number; NR, not reported; HR_{max}, maximal heart rate; mL/kg/min, millilitres per kilogram per minute; RER, respiratory exchange ratio; SD, standard deviation; TD, typically developing; VO_{2peak}, peak oxygen uptake.

