

## Supplementary Documents

### Supplement 1 – PICO framework

<b>Participants:</b> All humans Children Adults Males Females Athletes Non-athletes	<b>Intervention:</b> High dose/high intensity/high levels/ intensive/above recommended Dose response? Physical activity/exercise/training/
<b>Comparison:</b> NA	<b>Outcomes:</b> Arrhythmia Cardiovascular outcomes All-cause mortality Ischaemic heart disease Athletes heart Cardiomyopathy Cardiovascular disease

## Supplement 2: Search strategy

### OID

### EMBASE

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1. (exercis* or physical activity or training or exercise training).mp.	1. (exercis* or physical activity or training or exercise training).ti,ab
2. ((high or prolong* or sustained or vigorous or increas*) and dos*).mp.	2. ((high or prolong* or sustained or vigorous or increas*) and dos*).ti,ab
3. (marathon or cross country ski* or iron man* or triath* or ultra distance or endurance cycl* or endurance row* or endurance kayak* or olympi* or professional athlete or elite performance).mp	3. (marathon or cross country ski* or iron man* or triath* or ultra distance or endurance cycl* or endurance row* or endurance kayak* or olympi* or professional athlete or elite performance).ti,ab
4. (colleg* or university or club or recreational).mp.	4. (colleg* or university or club or recreational).ti,ab
5. (cycl* or row* or swim* or kayak* or run* or aerobic or endurance).mp.	5. (cycl* or row* or swim* or kayak* or run* or aerobic or endurance).ti,ab
6. arrhythmia*.mp. or exp Arrhythmias, Cardiac/ or arrhythmia cardiac.mp.	6. arrhythmia*.ti,ab or exp Heart arrhythmia/ or arrhythmia cardiac.ti,ab
7. (tachyarrhythmia or tachycardia).mp. or exp Tachycardia/	7. (tachyarrhythmia or tachycardia).ti,ab or exp Tachycardia/
8. (bradycardia or bradyarrhythmia).mp. or exp Bradycardia/	8. (bradycardia or bradyarrhythmia).ti,ab or exp Bradycardia/
9. ECG chang*.mp.	9. ECG chang*.ti,ab
10. Heart block.mp. or exp Heart Block/	10. Heart block.ti,ab or exp Heart Block/
11. (cardiovascular disease* or heart disease*).mp. or Cardiovascular Diseases/ or cardiovascular outcome*.mp.	11. (cardiovascular disease* or heart disease*).ti,ab or Cardiovascular Disease/ or cardiovascular outcome*.ti,ab

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| 12. (Cardiovascular adj5 mortality).mp.  | 12. (Cardiovascular adj5 mortality).ti,ab   |
| 13. isch* heart disease.mp. or Myocardial<br>Ischaemia/ or myocardial isch*.mp. or<br>Myocardial Infarction/   | 13. isch* heart disease.ti,ab or Heart muscle<br>ischemia / or myocardial isch*.ti,ab or Heart<br>infarction/ |
| 14. cardiomyopath*.mp. or exp<br>Cardiomyopathies/   | 14. cardiomyopath*.ti,ab or exp<br>Cardiomyopathy/  |
| 15. athlete* heart.mp. or Hypertrophy, Left<br>Ventricular/ or Hypertrophy, Right Ventricular/<br>or Arrhythmogenic Right Ventricular<br>Dysplasia/ or Cardiomyopathy, Hypertrophic/<br>or Cardiomyopathy, Restrictive/ or<br>Cardiomyopathy, Dilated/ | 15. athlete* heart.ti,ab or exp Heart<br>hypertrophy/ or heart right ventricle dysplasia/                     |
| 16. heart failure.mp. or Heart Failure/  | 16. heart failure.ti,ab or exp Heart Failure/   |
| 17. 1 and 2  | 17. 1 and 2   |
| 18. 4 and 17   | 18. 4 and 17  |
| 19. 5 and 17   | 19. 5 and 17  |
| 20. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or<br>14 or 15 or 16  | 20. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or<br>14 or 15 or 16   |
| 21. 3 or 18 or 19  | 21. 3 or 18 or 19   |
| 22. 20 and 21  | 22. 20 and 21   |

### Supplement 3 – Impact of excluding the largest studies

<b>Number of Studies Excluded (in size order)</b>	<b>Percentage Female Recruitment</b>
1	40.3%
2	41.6%
3	43.8%
4	38.7%
5	43.0%
6	36.2%
7	35.1%
8	24.6%
9	28.8%
10	18.8%
11	14.8%
12	16.4%
13	17.9%
14	19.6%
15	21.5%
16	19.0%
17	20.6%
18	21.6%
19	20.6%
20	22.1%

## Supplement 4 – Bibliography of all studies included in analysis

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**Supplement 5 – Table showing characteristics of the studies included within the scoping review**

<b>Study Number</b>	<b>Harvard Reference</b>	<b>Number of participants</b>	<b>Number of females</b>	<b>Percentage female</b>	<b>Location</b>	<b>Exercise Type</b>
1	Starekova et al. 2020	58	0	0.0%	European	Other
2	Mango et al. 2020	516	204	39.5%	European	Mixed
3	Pelliccia et al 2020	4595	1610	35.0%	European	Mixed
4	D'Silva et al 2020	68	32	47.1%	European	Running
5	Bjerring et al. 2020	36	12	33.3%	European	Cross-Country Skiing
6	Lewicka-Potocka et al. 2020	49	0	0.0%	European	Running
7	Bernardino et al. 2020	166	74	44.6%	European	Triathlon
8	Tahir et al. 2020	50	0	0.0%	European	Triathlon
9	D'Silva et al 2020	120	60	50.0%	European	Running
10	Miranda et al. 2020	88	26	29.5%	Americas	Other
11	Kunutsor et al. 2020	1949	0	0.0%	European	Cross-Country Skiing
12	Hosatte-Ducassy et al. 2020	99	41	41.4%	Americas	Triathlon
13	Dawkins et al. 2019	66	13	19.7%	European	Triathlon



14	Bjerring et al. 2019	48	14	29.2%	European	Cross-Country Skiing
15	Kunutsor et al 2019	1809	0	0.0%	European	Cross-Country Skiing
16	Jin et al 2019	501690	250664	50.0%	Western Pacific	Other
17	Major et al. 2019	363	109	30.0%	European	Mixed
18	Edwards and Loprinzi 2019	6694	3481	52.0%	Americas	Other
19	Hochsmann et al. 2019	137	97	70.8%	Americas	Other
20	Scheer et al 2019	1113	606	54.4%	Americas	Mixed
21	Malek et al 2019	40	0	0.0%	European	Running
22	Leckie et ak 2019	165	62	37.6%	European	Running
23	Hirata et al. 2019	12	3	25.0%	Western Pacific	Running
24	D'Ascenzi et al. 2019	1058	402	38.0%	European	Mixed
25	Zebrowska et al. 2019	14	0	0.0%	European	Running
26	Svedberg et al. 2019	736102	256378	34.8%	European	Cross-Country Skiing
27	Zorzi et al 2018	270	41	15.2%	European	Mixed
28	Gabrielli et al. 2018	16	0	0.0%	Americas	Running
29	Kaletka et al. 2018	40	0	0.0%	European	Running

30	Bjerring et al. 2018	101	41	40.6%	European	Cross-Country Skiing
31	Opondo et al. 2018	61	35	57.4%	Americas	Other
32	Antero-jacquemin et al. 2018	2814	696	24.7%	European	Mixed
33	Krumm et al. 2018	18	3	16.7%	European	Mixed
34	Scherr et al 2018	422	217	51.4%	Americas	Mixed
35	Vassalle et al. 2018	18	3	16.7%	European	Running
36	Tahir et al. 2018	119	43	36.1%	European	Triathlon
37	Vicent et al. 2018	117	8	6.8%	European	Mixed
38	Trullas et al. 2018	25	4	16.0%	European	Running
39	Harris et al. 2017	135	20	14.8%	Americas	Triathlon
40	Radonic et al. 2017	233	0	0.0%	European	Mixed
41	Herm et al. 2017	109	26	23.9%	European	Running
42	Roberts et al. 2017	50	0	0.0%	Americas	Running
43	Aengevaeren et al. 2017	284	0	0.0%	European	Mixed
44	Skadberg et al. 2017	97	23	23.7%	European	Mixed
45	Rosin 2017	54	0	0.0%	Americas	Running

46	Pelliccia et al. 2017	2352	919	39.1%	European	Mixed
47	Bonsignore et al. 2017	71	9	12.7%	Americas	Running
48	Dupont et al. 2017	24	0	0.0%	European	Triathlon
49	D'Ascenzi et al. 2017	1009	362	35.9%	European	Mixed
50	Ujka et al. 2017	92	22	23.9%	European	Running
51	Merghani et al. 2017	244	84	34.4%	European	Running
52	Perrin et al. 2016	287	103	35.9%	European	Mixed
53	Abdullah et al. 2016	92	25	27.2%	Americas	Other
54	Sanz de la Garza et al. 2016	60	0	0.0%	European	Running
55	Clauss et al. 2016	30	0	0.0%	European	Running
56	Stoggl et al. 2016	21	8	38.1%	European	Cross-Country Skiing
57	Calvo et al. 2016	172	22	12.8%	European	Other
58	Myrstad et al. 2016	4952	318	6.4%	European	Cross-Country Skiing
59	Konopka et al. 2016	117	53	45.3%	European	Other
60	Lemez et al. 2016	205	0	0.0%	Americas	Mixed
61	Hallmarker et al. 2016	204038	77534	38.0%	European	Cross-Country Skiing

62	Martin-Beaulieu et al. 2016	22	13	59.1%	Americas	Running
63	Montiel et al. 2016	18	18	100.0%	European	Running
64	Zha et al. 2015	60	30	50.0%	Americas	Running
65	Lacey et al. 2015	12203	0	0.0%	Western Pacific	Other
66	Loprinzi et al. 2015	16049	8121	50.6%	Americas	Other
67	Grabs et al. 2015	20	0	0.0%	European	Running
68	Szauder et al. 2015	53	0	0.0%	European	Running
69	Arem et al. 2015	661137	369652	55.9%	Americas	Other
70	Tsifilikas et al. 2015	50	0	0.0%	European	Running
71	Antero-Jacquemin et al. 2015	2812	726	25.8%	European	Mixed
72	Davis et al. 2015	71	33	46.5%	Americas	Other
73	Zilinski et al. 2015	45	0	0.0%	Americas	Running
74	Gram et al. 2015	61	0	0.0%	European	Other
75	Demirelli et al. 2015	73	0	0.0%	European	Running
76	Caselli et al. 2015	1299	526	40.5%	European	Mixed
77	McClellan et al. 2015	56	0	0.0%	European	Mixed

78	Lord et al. 2015	15	1	6.7%	Americas	Running
79	Kettunen et al. 2015	4387	0	0.0%	European	Mixed
80	Jouffroy et al. 2015	66	0	0.0%	European	Running
81	Caselli et al. 2015	200	79	39.5%	European	Mixed
82	Vance et al. 2014	47	0	0.0%	Americas	Running
83	Antero-Jacquemin et al. 2014	255	0	0.0%	European	Other
84	Myrstad et al. 2014	6358	0	0.0%	European	Cross-Country Skiing
85	Franco et al. 2014	19	5	26.3%	Americas	Running
86	Rimensberger et al. 2014	105	0	0.0%	European	Running
87	Myrstad et al. 2014	3364	0	0.0%	European	Cross-Country Skiing
88	Mohlenkamp et al. 2014	1188	0	0.0%	European	Running
89	Hattasch et al. 2014	22	0	0.0%	European	Running
90	Wilhelm et al. 2014	11	0	0.0%	European	Running
91	Leischik et al. 2014	51	0	0.0%	European	Triathlon
92	Leischik and Spelsberg 2014	87	33	37.9%	European	Triathlon
93	Kim et al. 2014	249	0	0.0%	Western Pacific	Running

94	Dalla Vecchia et al. 2014	35	4	11.4%	Americas	Running
95	Marijon et al. 2013	786	0	0.0%	European	Cross-Country Skiing
96	Denham et al. 2013	130	0	0.0%	European	Running
97	Gaudreault et al. 2013	20	14	70.0%	Americas	Running
98	Simsek et al. 2013	77	0	0.0%	European	Mixed
99	Williams and Franklin 2013	46907	27854	59.4%	European	Mixed
100	Andersen et al. 2013	54560	5443	10.0%	European	Cross-Country Skiing
101	Kim et al. 2013	59	0	0.0%	Western Pacific	Running
102	Swift et al. 2013	464	464	100.0%	Americas	Other
103	Karstoft et al. 2013	8	1	12.5%	European	Running
104	Vitarelli et al. 2013	140	0	0.0%	European	Mixed
105	Franzen et al. 2013	40	0	0.0%	European	Mixed
106	Van Buuren et al. 2013	291	0	0.0%	European	Other
107	Iellamo et al. 2013	20	0	0.0%	European	Other
108	Iellamo et al. 2013	20	0	0.0%	European	Other
109	Roberts et al. 2013	548092	168227	30.7%	Americas	Running

110	Haeusler et al. 2012	110	27	24.5%	European	Running
111	Kalstedt et al. 2012	25	4	16.0%	Americas	Running
112	Van Buuren et al. 2012	33	0	0.0%	European	Other
113	Mathews et al. 2012	3718336	1463276	39.4%	Americas	Running
114	Swift et al. 2012	464	464	100.0%	Americas	Other
115	Scherr et al. 2012	277	0	0.0%	European	Running
116	Wilhelm et al. 2012	138	68	49.3%	European	Running
117	Stoutenberg Et Al 2012	42	0	0.0%	Americas	Running
118	Kim et al. 2012	10871000	4862670	44.7%	Americas	Running
119	Wilhelm et al. 2012	70	0	0.0%	European	Running
120	Caselli et al. 2012	92	28	30.4%	European	Other
121	Swift Et Al 2012	94	94	100.0%	Americas	Other
122	Conti et al. 2012	35	0	0.0%	European	Mixed
123	Wilhelm et al. 2011	138	68	49.3%	European	Running
124	Wilhelm et al. 2011	70	0	0.0%	European	Running
125	Krol et al. 2011	79	14	17.7%	European	Mixed

126	Grimsmo et al. 2011	122	0	0.0%	European	Cross-Country Skiing
127	Durand et al. 2011	527	0	0.0%	Americas	Other
128	Minns et al. 2011	87	41	47.1%	Americas	Running
129	Hanssen et al. 2011	30	0	0.0%	European	Running
130	Pelliccia et al. 2010	2317	1017	43.9%	European	Mixed
131	Banfi et al. 2010	15	2	13.3%	European	Running
132	Pelliccia et al. 2010	114	25	21.9%	European	Mixed
133	Trivax et al. 2010	25	13	52.0%	Americas	Running
134	Grimsmo et al. 2010	149	0	0.0%	Americas	Cross-Country Skiing
135	Andersson et al. 2010	20	0	0.0%	European	Cross-Country Skiing
136	O'Hanlon et al. 2010	17	0	0.0%	European	Running
137	Scharf et al. 2010	26	0	0.0%	European	Triathlon
138	Indermuhle et al. 2009	60	4	6.7%	European	Triathlon
139	Swiatowiec et al. 2009	73	20	27.4%	European	Mixed
140	Her et al. 2009	75	25	33.3%	Western Pacific	Running
141	Hawkins, 2009	16	0	0.0%	Americas	Mixed



142	Nassenstein, 2009	108	0	0.0%	European	Running
143	Breuckmann et al. 2009	102	0	0.0%	European	Running
144	Nottin et al. 2009	23	0	0.0%	European	Triathlon
145	Heinz et al 2009	80	41	51.3%	European	Mixed
146	Lippi, 2008	17	0	0.0%	European	Running
147	Lippi et al 2008	17	0	0.0%	European	Running
148	Molina L, 2008	557	0	0.0%	European	Running
149	Kasikcioglu et al 2008	13	0	0.0%	European	Running
150	Poh, 2008	39	16	41.0%	Americas	Other
151	Koller et al. 2008	59	7	11.9%	European	Running
152	Lalande, 2007	19	0	0.0%	Western Pacific	Other
153	Belonje, 2007	62862	47775	76.0%	European	Mixed
154	Carlsson M, 2007	36	13	36.1%	European	Triathlon
155	Musat et al. 2007	30	30	100.0%	European	Running
156	Perseghin et al. 2007	33	0	0.0%	European	Running
157	Lippi, 2006	202	0	0.0%	European	Mixed

158	Tian Y, 2006	10	0	0.0%	Western Pacific	Running
159	Petersen et al 2006	81	37	45.7%	European	Mixed
160	Indermuhle A, 2006	93	60	64.5%	European	Mixed
161	Middleton , 2006	14	1	7.1%	European	Running
162	Saenz et al. 2006	35	6	17.1%	Americas	Running
163	Banfi, 2005	49	4	8.2%	European	Triathlon
164	Scharhag, 2005	105	13	12.4%	European	Running
165	Arrese, 2005	188	54	28.7%	European	Running
166	Real et al 2005	22	0	0.0%	European	Running
167	Makan, 2005	1150	309	26.9%	European	Running
168	Pavlik, 2005	65	0	0.0%	European	Mixed
169	Whyte et al. 2005	52	9	17.3%	European	Running
170	Vidotto et al. 2005	25	13	52.0%	European	Running
171	Whyte, 2004	442	136	30.8%	European	Mixed
172	Bennekens et al 2004	9	2	22.2%	European	Running
173	Date, 2003	51	0	0.0%	Western Pacific	Mixed

174	Galetta, 2003	48	0	0.0%	European	Mixed
175	Iwasaki, 2003	11	5	45.5%	Americas	Other
176	Herrmann et al. 2003	100	13	13.0%	European	Mixed
177	Draheim et al. 2003	145	72	49.7%	European	Mixed
178	Shave et al. 2002	37	0	0.0%	European	Running
179	Palazzuoli, 2002	45	0	0.0%	European	Running
180	Apple, 2002	19	12	63.2%	Americas	Running
181	Palazzuoli, 2001	43	0	0.0%	European	Running
182	Siegel, 2001	82	0	0.0%	Americas	Running
183	Matsuo et al 2001	48	10	20.8%	Western Pacific	Mixed
184	Ohba, 2001	13	0	0.0%	Western Pacific	Running
185	Claessens et al. 2001	74	0	0.0%	European	Triathlon
186	Ginsburg et al. 2001	57	19	33.3%	Americas	Triathlon
187	Claessens, 2000	74	0	0.0%	European	Triathlon
188	Dressendorfer, 2000	21	0	0.0%	Americas	Running
189	Hildick-Smith, 2000	52	0	0.0%	European	Mixed

190	Warburton et al. 2000	9	0	0.0%	Americas	Triathlon
191	Pelliccia, 2000	1005	260	25.9%	European	Mixed
192	Mattusch et al. 2000	14	0	0.0%	European	Running
193	Claessens et al. 2000	74	0	0.0%	European	Triathlon
194	Claessens, 1999	74	0	0.0%	European	Triathlon
195	Claessens, 1999	74	0	0.0%	European	Triathlon
196	Lucia et al. 1999	10	1	10.0%	European	Running
197	Whyte,1999	30	0	0.0%	European	Triathlon
198	Yu et al. 1999	28	6	21.4%	Americas	Triathlon
199	Damm et al. 1999	95	0	0.0%	European	Mixed
200	Mayet, 1999	33	0	0.0%	European	Mixed
201	Pelliccia, 1999	1309	352	26.9%	European	Mixed
202	Biffi et al. 1999	153	0	0.0%	European	Mixed
203	Whyte et al. 1999	29	0	0.0%	European	Mixed
204	Furlanello, 1998	1772	308	17.4%	European	Mixed
205	Rodriguez-Plaza	50	0	0.0%	Americas	Running

206	Bergstrom, 1997	879	402	45.7%	European	Running
207	Sarna, 1997	1712	0	0.0%	European	Mixed
208	Williams, 1997	8283	0	0.0%	Americas	Running
209	Cubeddu et al. 1997	50	0	0.0%	Americas	Running
210	Henriksen, 1996	127	0	0.0%	European	Mixed
211	Ketelhut, 1996	30	0	0.0%	European	Running
212	Ginsburg, 1996	39	13	33.3%	Americas	Triathlon
213	Pelliccia, 1996	665	665	100.0%	European	Mixed
214	Williams, 1996	1837	1837	100.0%	Americas	Running
215	Biffi et al. 1996	60	0	0.0%	European	Mixed
216	Ziman and Jeenah 1995	82	0	0.0%	Africa	Running
217	Siegel, 1995	8	0	0.0%	Americas	Running
218	Kokkinos et al. 1995	2906	0	0.0%	Americas	Running
219	Maron, 1994	14	1	7.1%	Americas	Mixed
220	Luurila, 1994	37	0	0.0%	European	Cross-Country Skiing
221	Spirito, 1994	947	209	22.1%	European	Mixed

222	Martinez-Mas, 1994	42	0	0.0%	European	Running
223	Imai, 1994	60	0	0.0%	Western Pacific	Cross-Country Skiing
224	Sivertssen, 1994	24	11	45.8%	European	Cross-Country Skiing
225	Sarna, 1993	2613	0	0.0%	European	Mixed
226	Maron, 1993	6	0	0.0%	European	Mixed
227	Riley-Hagan et al. 1992	46	46	100.0%	Americas	Mixed
228	Ogawa, 1991	54	0	0.0%	Western Pacific	Cross-Country Skiing
229	Stray-Gundersen, 1991	176	48	27.3%	Americas	Cross-Country Skiing
230	Morris, 1990	9376	0	0.0%	European	Other
231	Kostka, 1989	194	0	0.0%	European	Running
232	Smith, 1989	30	3	10.0%	Americas	Running
233	Rocker, 1986	16	0	0.0%	European	Running
234	Siegel, 1985	15	0	0.0%	Americas	Running
235	Lie, 1985	2136	0	0.0%	European	Cross-Country Skiing
236	Paffenbarger, 1984	572	0	0.0%	Americas	Other
237	Apple, 1984	12	0	0.0%	Americas	Running

238	Lie, 1984	122	0	0.0%	European	Cross-Country Skiing
239	Apple, 1983	2	0	0.0%	Americas	Running
240	Siegel, 1983	35	0	0.0%	Americas	Running
241	Deshaies, 1982	95	31	32.6%	Americas	Mixed
242	Ohman, 1982	15	0	0.0%	European	Running
243	Virmani et al. 1982	30	0	0.0%	Americas	Running
244	Siegel, 1981	35	0	0.0%	Americas	Running
245	Murayama and Kuroda 1980	365	64	17.5%	Western Pacific	Triathlon
246	Olivier, 1978	48	0	0.0%	Africa	Running
247	Lie, 1978	149	0	0.0%	European	Cross-Country Skiing
248	Milvy, 1977	9958	0	0.0%	Americas	Running
249	Nakamoto, 1969	72	27	37.5%	Western Pacific	Running
250	Smith, 1964	21	0	0.0%	Western Pacific	Mixed