Exercise for COVID-19: real-time meta analysis of 66 studies

@CovidAnalysis, March 2024, Version 41
https://c19early.org/exmeta.html

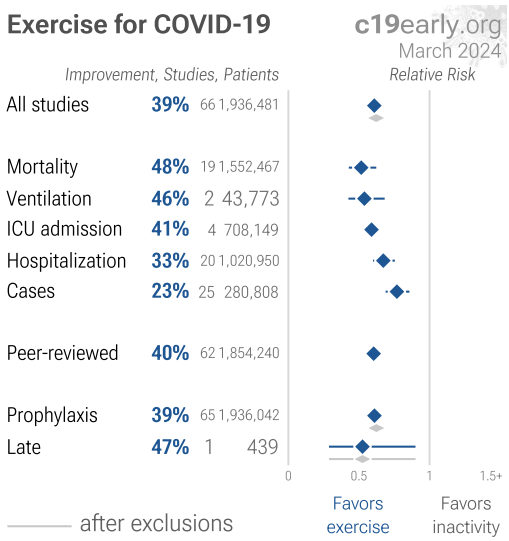
Abstract

Statistically significant lower risk is seen for mortality, ventilation, ICU admission, hospitalization, progression, recovery, and cases. 51 studies from 51 independent teams in 24 countries show statistically significant improvements.

Meta analysis using the most serious outcome reported shows 39% [34-44%] lower risk. Results are similar for higher quality and peer-reviewed studies.

Results are robust — in exclusion sensitivity analysis 54 of 66 studies must be excluded to avoid finding statistically significant efficacy in pooled analysis.

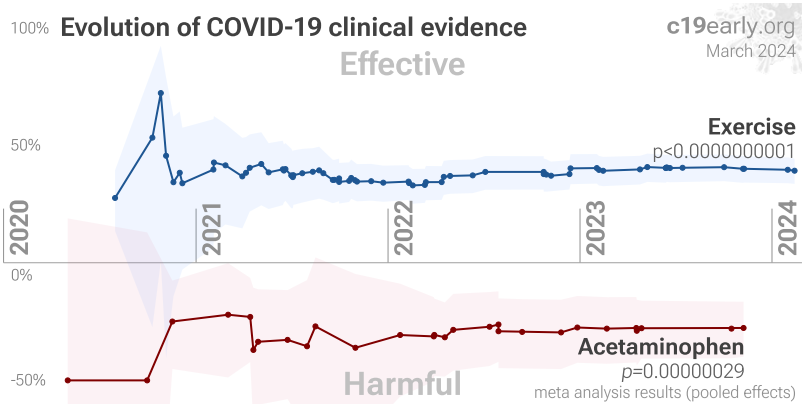
Results are consistent with the overall risk of all cause mortality based on cardiorespiratory fitness — *Laukkanen* show RR 0.55 [0.50-0.61] for the top vs. bottom tertiles.



Most studies analyze exercise/physical activity levels before infection, comparing regular/moderate exercise and lower/no exercise. Risk may increase with more extreme activity levels.

No treatment or intervention is 100% effective. All practical, effective, and safe means should be used based on risk/benefit analysis.

All data to reproduce this paper and sources are in the appendix. Other meta analyses show significant improvements with exercise for mortality *Ezzatvar, Halabchi, Liu, Rahmati, Sittichai*, ICU admission *Rahmati*, hospitalization *Ezzatvar, Halabchi, Li, Rahmati*, severity *Ezzatvar, Liu, Sittichai*, and cases *Ezzatvar*.



HIGHLIGHTS

Exercise reduces risk for COVID-19 with very high confidence for mortality, ICU admission, hospitalization, recovery, cases, and in pooled analysis, and low confidence for ventilation and progression.

Exercise was the 9th treatment shown effective with ≥3 clinical studies in October 2020, now known with $p < 0.00000000001$ from 66 studies.

We show traditional outcome specific analyses and combined evidence from all studies.

Real-time updates and corrections, transparent analysis with all results in the same format, consistent protocol for 66 treatments.

66 exercise COVID-19 studies

c19early.org
March 2024

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Brawner	74%	0.26 [0.11-0.58]	hosp.	n/a	n/a
Tret'yakov	98%	0.02 [0.00-0.27]	severe case	0/27	53/266
Gao	-105%	2.05 [1.39-3.02]	cases	case control	
Ho	35%	0.65 [0.48-0.89]	hosp.	213/123,588	59/14,887
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Zhang	26%	0.74 [0.48-1.14]	death	n/a	n/a
Li	81%	0.19 [0.05-0.74]	severe case	n/a	n/a
Tavakol	69%	0.31 [0.10-1.02]	severe case	3/64	19/124
Yates	45%	0.55 [0.38-0.79]	death	72/163,912	62/30,119
Holt	17%	0.83 [0.63-1.09]	cases	15,227 (all patients)	
Cho	53%	0.47 [0.26-0.87]	death	case control	
Sallis	59%	0.41 [0.22-0.76]	death	11/3,118	170/6,984
Christensen	63%	0.37 [0.16-0.85]	death	543 (n)	529 (n)
Lobelo	20%	0.80 [0.66-0.97]	hosp.	2,121 (n)	1,648 (n)
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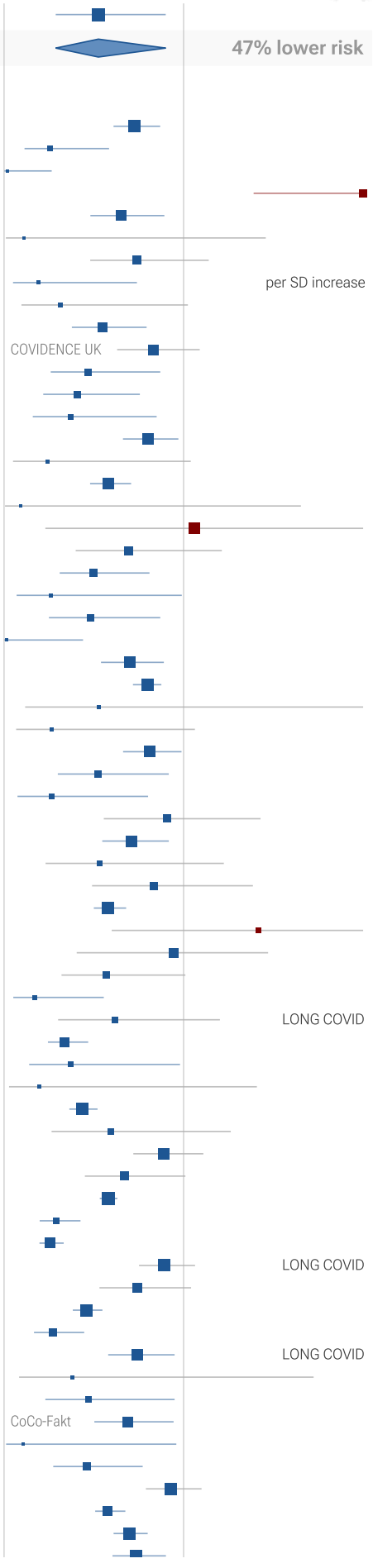
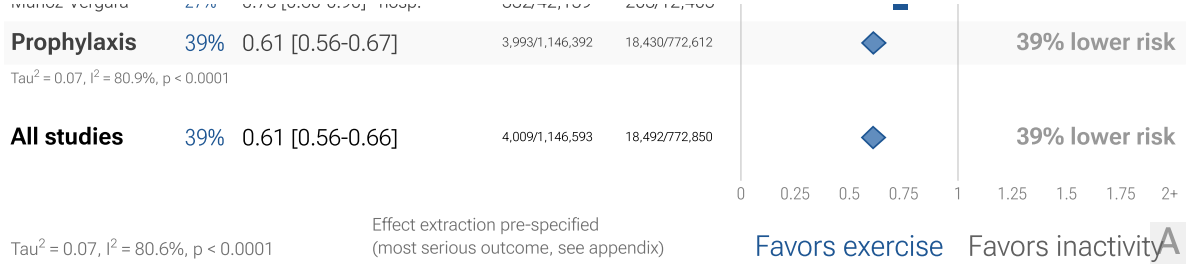
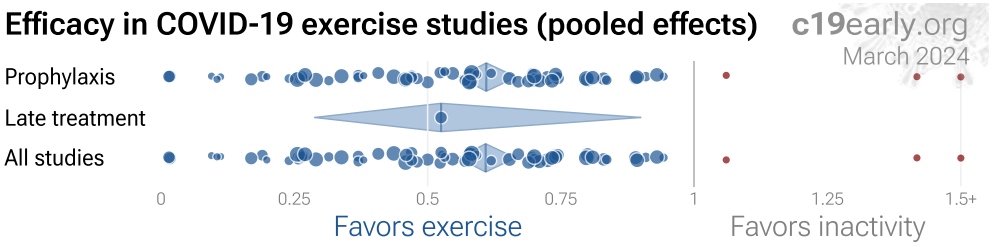



Prophylaxis 39% 0.61 [0.56-0.67] 3,993/1,146,392 18,430/772,612 39% lower risk
Tau² = 0.07, I² = 80.9%, p < 0.0001
All studies 39% 0.61 [0.56-0.66] 4,009/1,146,593 18,492/772,850 39% lower risk
0 0.25 0.5 0.75 1 1.25 1.5 1.75 2+
Tau² = 0.07, I² = 80.6%, p < 0.0001
Effect extraction pre-specified
(most serious outcome, see appendix)
Favors exercise
Favors inactivity

A


Efficacy in COVID-19 exercise studies (pooled effects)
c19early.org
March 2024
Prophylaxis
Late treatment
All studies
0 0.25 0.5 0.75 1 1.25 1.5+
Favors exercise
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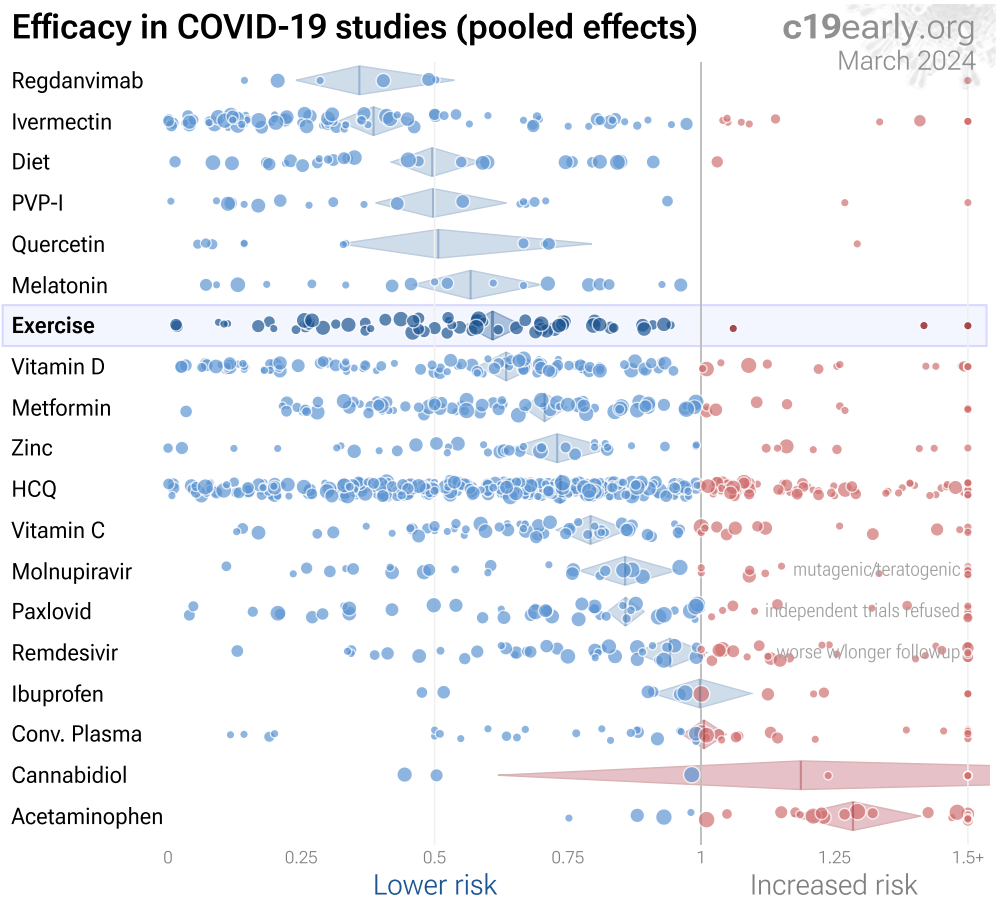
B


Efficacy in COVID-19 studies (pooled effects)
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Regdanvimab
Ivermectin
Diet
PVP-I
Quercetin
Melatonin
Exercise
Vitamin D
Metformin
Zinc
HCQ
Vitamin C
Molnupiravir
Paxlovid
Remdesivir
Ibuprofen
Conv. Plasma
Cannabidiol
Acetaminophen
mutagenic/teratogenic
independent trials refused
worse w/longer follow-up
0 0.25 0.5 0.75 1 1.25 1.5+
Lower risk
Increased risk

C

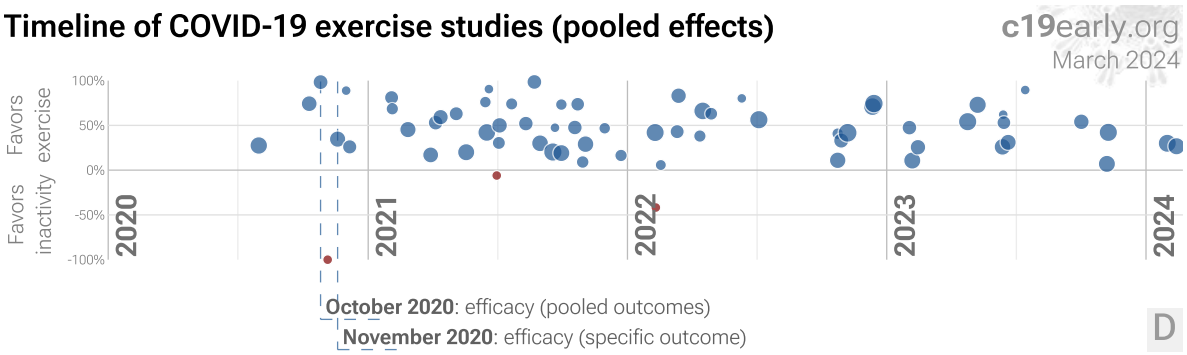

Figure 1. **A. Random effects meta-analysis.** This plot shows pooled effects, see the specific outcome analyses for individual outcomes, and the heterogeneity section for discussion. Effect extraction is pre-specified, using the most serious outcome reported. For details of effect extraction see the appendix. **B. Scatter plot showing the most serious outcome in all studies.** The diamond shows the results of random effects meta-analysis. **C. Results within the context of multiple COVID-19 treatments.** 0.6% of 6,686 proposed treatments show efficacy *c19early.org*. **D. Timeline of results in exercise studies.** The marked dates indicate the time when efficacy was known with a statistically significant improvement of ≥10% from ≥3 studies for pooled outcomes and one or more specific outcome. Efficacy based on specific outcomes was delayed by 0.8 months, compared to using pooled outcomes.

Introduction

Other infections. Efficacy with exercise has been shown for pneumonia *Kunutsor*.

Insufficient physical activity is a risk factor for many diseases and is common around the world with prevalence increasing over time, and over two times greater in high-income countries *Guthold*. For upper respiratory tract infections, research shows lower risk for moderate activity vs. a sedentary lifestyle, however risk may increase with more extreme activity levels *Nieman*.

Analysis. We analyze all significant studies reporting COVID-19 outcomes as a function of physical activity levels. Search methods, inclusion criteria, effect extraction criteria (more serious outcomes have priority), all individual study data, PRISMA answers, and statistical methods are detailed in Appendix 1. We present random effects meta-analysis results for all studies, studies within each treatment stage, individual outcomes, peer-reviewed studies, and higher quality studies.

Results

Table 1 summarizes the results for all studies, for peer-reviewed studies, after exclusions, and for specific outcomes. Figure 2, 3, 4, 5, 6, 7, 8, 9, and 10 show forest plots for random effects meta-analysis of all studies with pooled effects, mortality results, ventilation, ICU admission, hospitalization, progression, recovery, cases, and peer reviewed studies.

	Improvement	*Studies*	*Patients*	*Authors*
All studies	39% [34-44%] ****	66	1,936,481	600
After exclusions	38% [32-43%] ****	61	1,935,083	561
Peer-reviewed studies	40% [34-45%] ****	62	1,854,240	575
Mortality	48% [38-57%] ****	19	1,552,467	185
Ventilation	46% [32-57%] ****	2	43,773	18
ICU admission	41% [35-47%] ****	4	708,149	32
Hospitalization	33% [25-40%] ****	20	1,020,950	145
Recovery	58% [41-70%] ****	3	297	23
Cases	23% [14-31%] ****	25	280,808	275

Table 1. **Random effects meta-analysis for all studies, for peer-reviewed studies, after exclusions, and for specific outcomes.** Results show the percentage improvement with increased activity levels and the 95% confidence interval. * $p<0.05$ **** $p<0.0001$.

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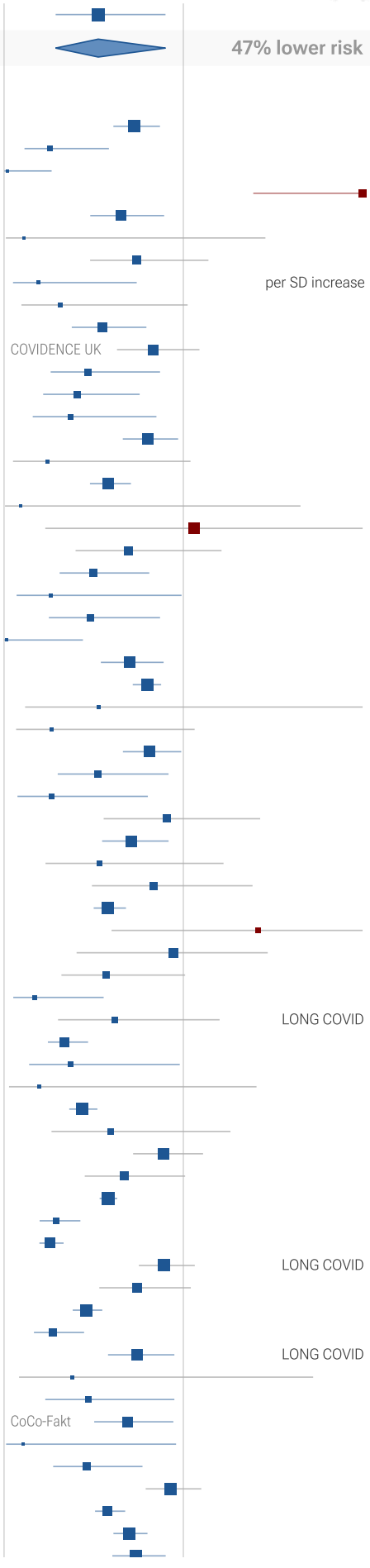

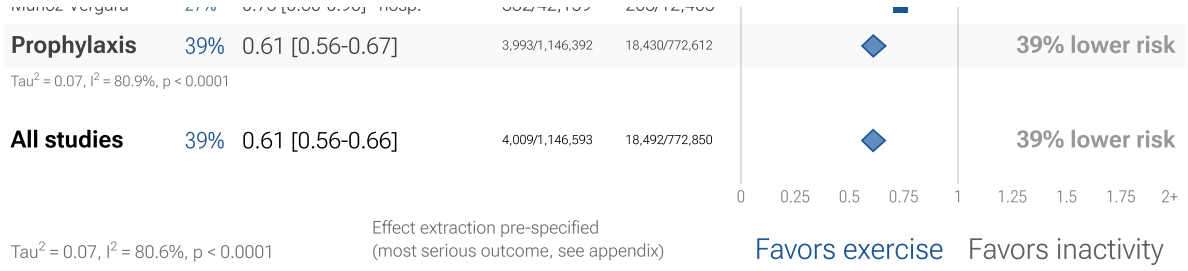

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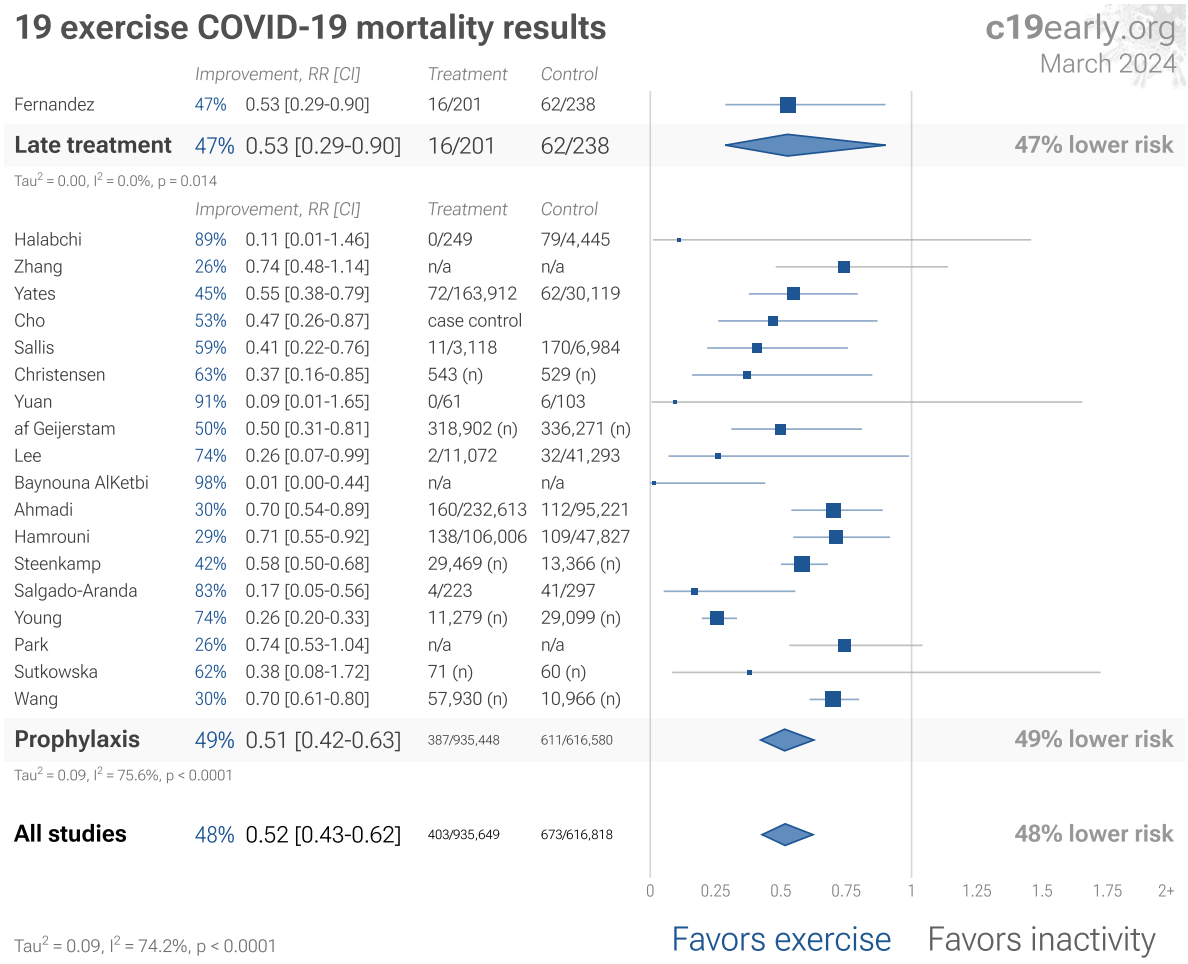

Figure 3. **Random effects meta-analysis for mortality results.**

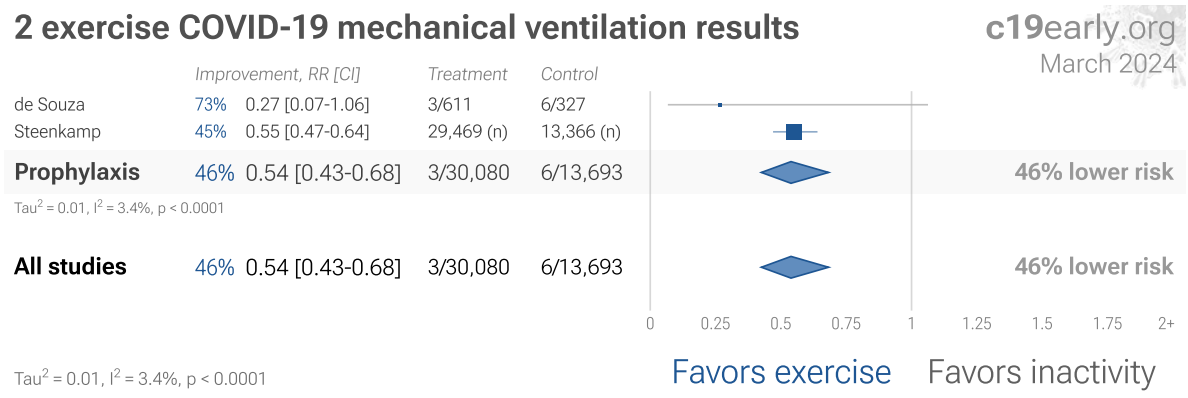

Figure 4. Random effects meta-analysis for ventilation.

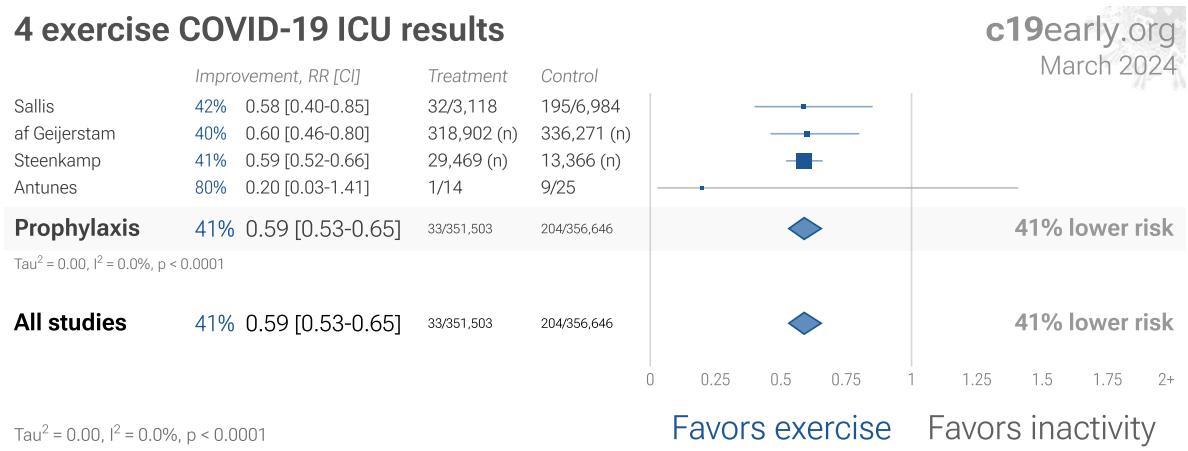

Figure 5. Random effects meta-analysis for ICU admission.

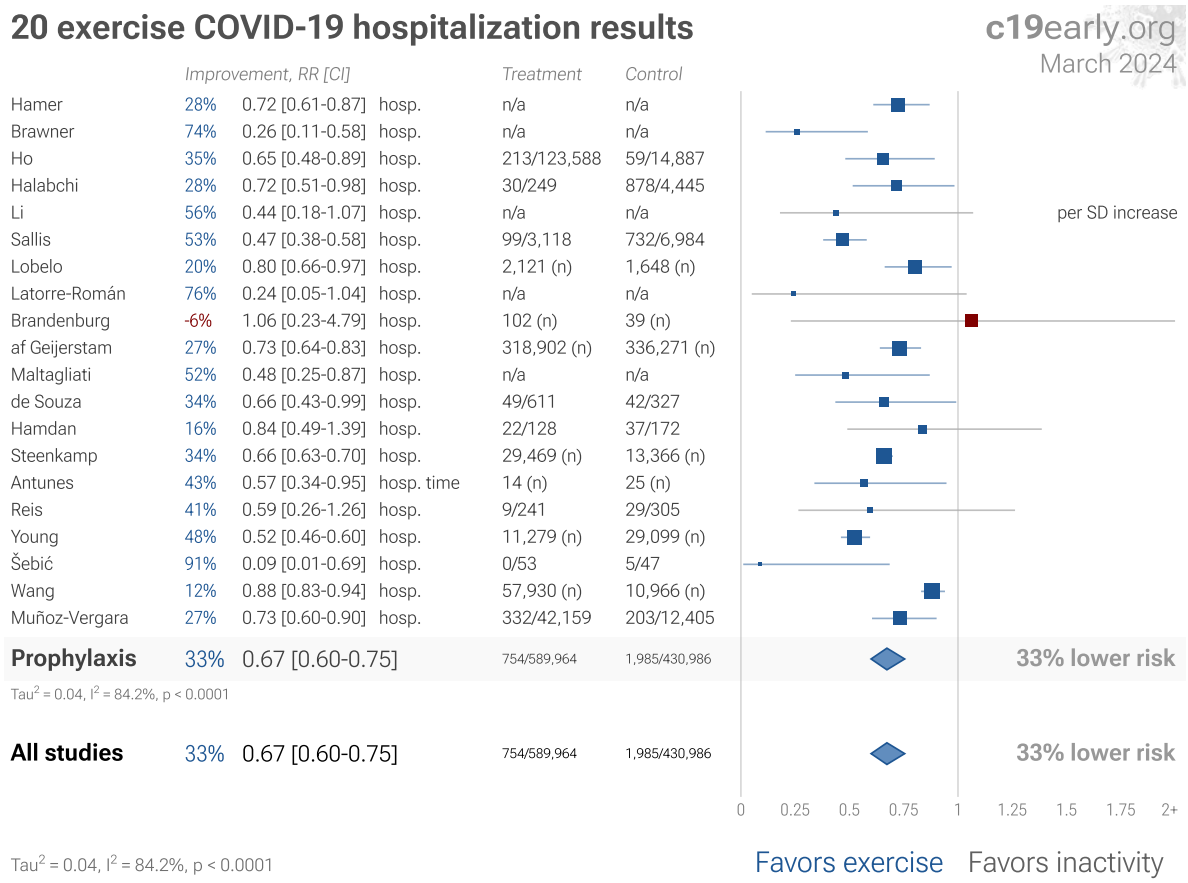

Figure 6. Random effects meta-analysis for hospitalization.

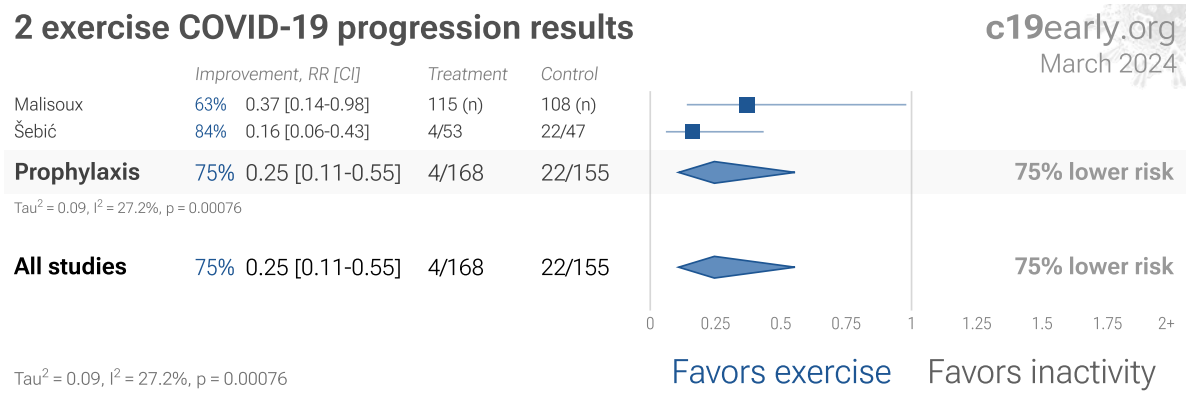

Figure 7. Random effects meta-analysis for progression.

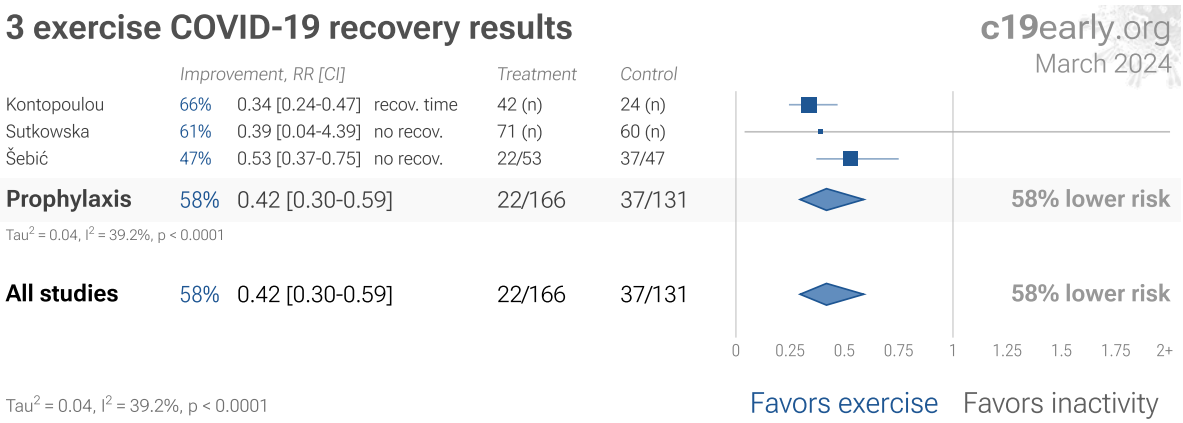

Figure 8. Random effects meta-analysis for recovery.

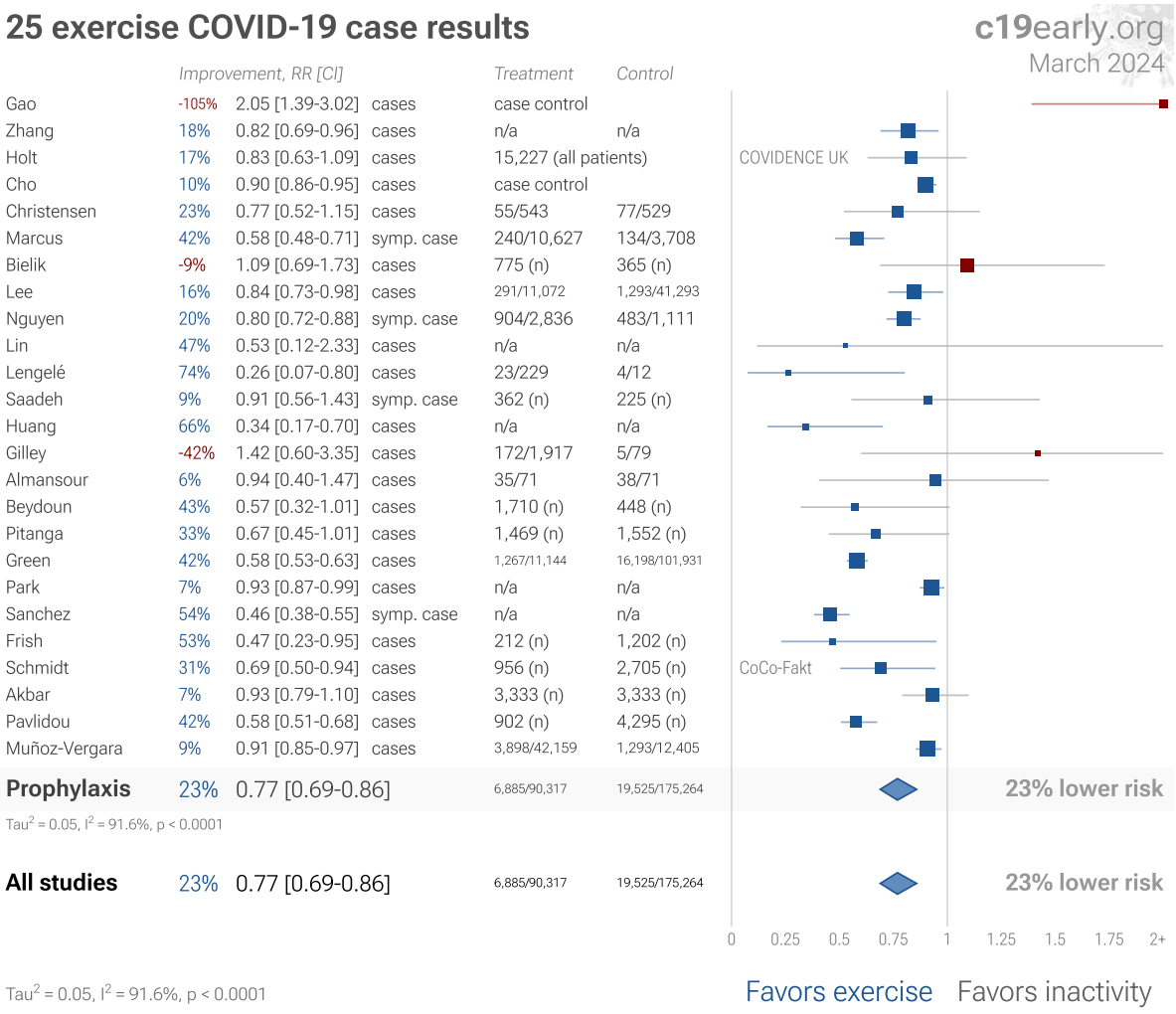

Figure 9. Random effects meta-analysis for cases.

62 exercise COVID-19 peer reviewed studies

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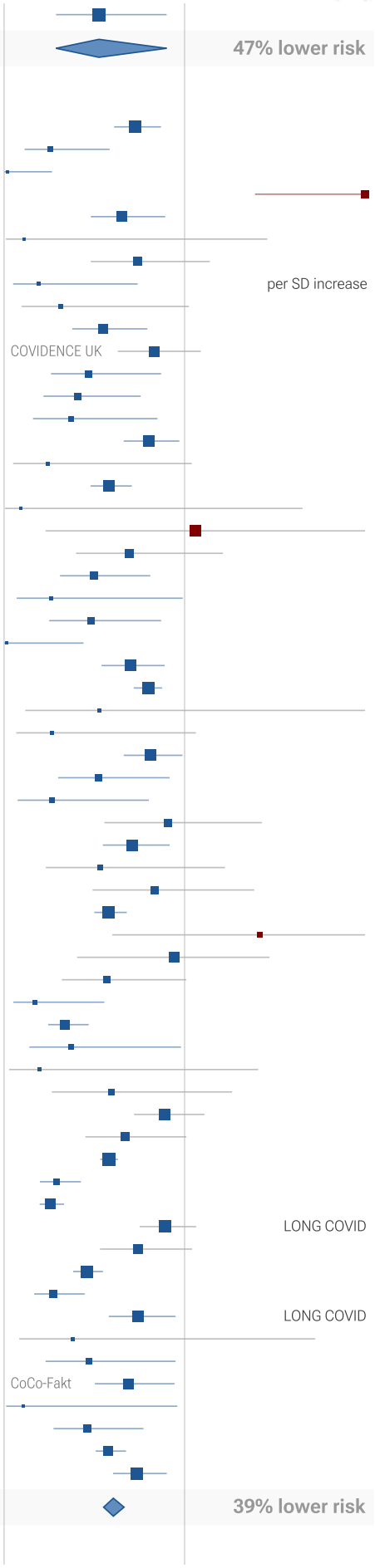
March 2024

	Improvement	RR [CI]		Treatment	Control
Fernandez	47%	0.53 [0.29-0.90]	death	16/201	62/238
Late treatment	47%	0.53 [0.29-0.90]		16/201	62/238

$Tau^2 = 0.00$, $I^2 = 0.0\%$, $p = 0.014$

	Improvement	RR [CI]		Treatment	Control
Hamer	28%	0.72 [0.61-0.87]	hosp.	n/a	n/a
Brawner	74%	0.26 [0.11-0.58]	hosp.	n/a	n/a
Tret'yakov	98%	0.02 [0.00-0.27]	severe case	0/27	53/266
Gao	-105%	2.05 [1.39-3.02]	cases	case control	
Ho	35%	0.65 [0.48-0.89]	hosp.	213/123,588	59/14,887
Halabchi	89%	0.11 [0.01-1.46]	death	0/249	79/4,445
Zhang	26%	0.74 [0.48-1.14]	death	n/a	n/a
Li	81%	0.19 [0.05-0.74]	severe case	n/a	n/a
Tavakol	69%	0.31 [0.10-1.02]	severe case	3/64	19/124
Yates	45%	0.55 [0.38-0.79]	death	72/163,912	62/30,119
Holt	17%	0.83 [0.63-1.09]	cases	15,227 (all patients)	
Cho	53%	0.47 [0.26-0.87]	death	case control	
Sallis	59%	0.41 [0.22-0.76]	death	11/3,118	170/6,984
Christensen	63%	0.37 [0.16-0.85]	death	543 (n)	529 (n)
Lobelo	20%	0.80 [0.66-0.97]	hosp.	2,121 (n)	1,648 (n)
Latorre-Román	76%	0.24 [0.05-1.04]	hosp.	n/a	n/a
Marcus	42%	0.58 [0.48-0.71]	symp. case	240/10,627	134/3,708
Yuan	91%	0.09 [0.01-1.65]	death	0/61	6/103
Brandenburg	-6%	1.06 [0.23-4.79]	hosp.	102 (n)	39 (n)
Bielik	30%	0.70 [0.40-1.21]	mod. case	775 (n)	365 (n)
af Geijerstam	50%	0.50 [0.31-0.81]	death	318,902 (n)	336,271 (n)
Lee	74%	0.26 [0.07-0.99]	death	2/11,072	32/41,293
Maltagliati	52%	0.48 [0.25-0.87]	hosp.	n/a	n/a
Baynouna AlKetbi	98%	0.01 [0.00-0.44]	death	n/a	n/a
Ahmadi	30%	0.70 [0.54-0.89]	death	160/232,613	112/95,221
Nguyen	20%	0.80 [0.72-0.88]	symp. case	904/2,836	483/1,111
Lin	47%	0.53 [0.12-2.33]	cases	n/a	n/a
de Souza	73%	0.27 [0.07-1.06]	ventilation	3/611	6/327
Mohsin	19%	0.81 [0.66-0.99]	severe case	86/258	224/544
Ekblom-Bak	48%	0.52 [0.30-0.92]	severe case	n/a	n/a
Lengelé	74%	0.26 [0.07-0.80]	cases	23/229	4/12
Saadeh	9%	0.91 [0.56-1.43]	symp. case	362 (n)	225 (n)
Hamrouni	29%	0.71 [0.55-0.92]	death	138/106,006	109/47,827
Huang	47%	0.53 [0.23-1.22]	severe case	7/74	16/90
Hamdan	16%	0.84 [0.49-1.39]	hosp.	22/128	37/172
Steenkamp	42%	0.58 [0.50-0.68]	death	29,469 (n)	13,366 (n)
Gilley	-42%	1.42 [0.60-3.35]	cases	172/1,917	5/79
Almansour	6%	0.94 [0.40-1.47]	cases	35/71	38/71
Beydoun	43%	0.57 [0.32-1.01]	cases	1,710 (n)	448 (n)
Salgado-Aranda	83%	0.17 [0.05-0.56]	death	4/223	41/297
Kontopoulou	66%	0.34 [0.24-0.47]	recov. time	42 (n)	24 (n)
Malisoux	63%	0.37 [0.14-0.98]	progression	115 (n)	108 (n)
Antunes	80%	0.20 [0.03-1.41]	ICU	1/14	9/25
Reis	41%	0.59 [0.26-1.26]	hosp.	9/241	29/305
Pływaczewska-J..	11%	0.89 [0.72-1.11]	m/s case	490 (n)	1,357 (n)
Pitanga	33%	0.67 [0.45-1.01]	cases	1,469 (n)	1,552 (n)
Green	42%	0.58 [0.53-0.63]	cases	1,267/11,144	16,198/101,931
Kapusta	71%	0.29 [0.20-0.43]	severe case	181 (n)	387 (n)
Young	74%	0.26 [0.20-0.33]	death	11,279 (n)	29,099 (n)
Wang	11%	0.89 [0.75-1.06]	PASC	274/691	283/594
Park	26%	0.74 [0.53-1.04]	death	n/a	n/a
Sanchez	54%	0.46 [0.38-0.55]	symp. case	n/a	n/a
Cardoso	73%	0.27 [0.17-0.45]	severe case	case control	
Feter	26%	0.74 [0.58-0.95]	PASC	52 (n)	95 (n)
Sutkowska	62%	0.38 [0.08-1.72]	death	71 (n)	60 (n)
Frish	53%	0.47 [0.23-0.95]	cases	212 (n)	1,202 (n)
Schmidt	31%	0.69 [0.50-0.94]	cases	956 (n)	2,705 (n)
Šebić	89%	0.11 [0.01-0.96]	oxygen	0/53	4/47
Hegazy	54%	0.46 [0.27-0.77]	m/s case	15/50	15/23
Pavlidou	42%	0.58 [0.51-0.68]	cases	902 (n)	4,295 (n)
Muñoz-Vergara	27%	0.73 [0.60-0.90]	hosp.	332/42,159	203/12,405
Prophylaxis	39%	0.61 [0.55-0.66]		3,993/1,081,789	18,430/756,785

$Tau^2 = 0.07$, $I^2 = 79.8\%$, $p < 0.0001$



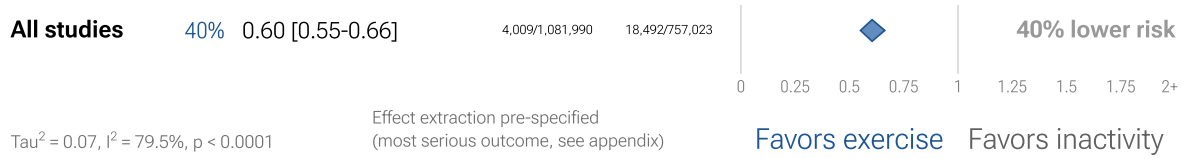


Figure 10. **Random effects meta-analysis for peer reviewed studies.** Effect extraction is pre-specified, using the most serious outcome reported, see the appendix for details. *Zeraatkar et al.* analyze 356 COVID-19 trials, finding no significant evidence that preprint results are inconsistent with peer-reviewed studies. They also show extremely long peer-review delays, with a median of 6 months to journal publication. A six month delay was equivalent to around 1.5 million deaths during the first two years of the pandemic. Authors recommend using preprint evidence, with appropriate checks for potential falsified data, which provides higher certainty much earlier. *Davidson et al.* also showed no important difference between meta analysis results of preprints and peer-reviewed publications for COVID-19, based on 37 meta analyses including 114 trials.

Exclusions

To avoid bias in the selection of studies, we analyze all non-retracted studies. Here we show the results after excluding studies with major issues likely to alter results, non-standard studies, and studies where very minimal detail is currently available. Our bias evaluation is based on analysis of each study and identifying when there is a significant chance that limitations will substantially change the outcome of the study. We believe this can be more valuable than checklist-based approaches such as Cochrane GRADE, which may underemphasize serious issues not captured in the checklists, overemphasize issues unlikely to alter outcomes in specific cases (for example, lack of blinding for an objective mortality outcome, or certain specifics of randomization with a very large effect size), and can be easily influenced by potential bias.

The studies excluded are as below. Figure 11 shows a forest plot for random effects meta-analysis of all studies after exclusions.

Brawner, unadjusted results with no group details.

de Souza, unadjusted results with no group details. Excluded results: mechanical ventilation.

Hegazy, unadjusted results with no group details.

Huang, unadjusted results with no group details. Excluded results: severe case.

Kontopoulou, unadjusted results with no group details.

Mohsin, unadjusted results with no group details.

Tret'yakov, unadjusted results with no group details.

Yuan, excessive unadjusted differences between groups. Excluded results: death.

61 exercise COVID-19 studies after exclusions

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March 2024

	Improvement, RR [CI]			Treatment	Control	
Fernandez	47%	0.53 [0.29-0.90]	death	16/201	62/238	
Late treatment	47%	0.53 [0.29-0.90]		16/201	62/238	47% lower risk
Tau^2 = 0.00, I^2 = 0.0%, p = 0.014						
	Improvement, RR [CI]			*Treatment*	*Control*	
Hamer	28%	0.72 [0.61-0.87]	hosp.	n/a	n/a	
Gao	-105%	2.05 [1.39-3.02]	cases	case control		
Ho	35%	0.65 [0.48-0.89]	hosp.	213/123,588	59/14,887	
Halabchi	89%	0.11 [0.01-1.46]	death	0/249	79/4,445	
Zhang	26%	0.74 [0.48-1.14]	death	n/a	n/a	
Li	81%	0.19 [0.05-0.74]	severe case	n/a	n/a	per SD increase
Tavakol	69%	0.31 [0.10-1.02]	severe case	3/64	19/124	
Yates	45%	0.55 [0.38-0.79]	death	72/163,912	62/30,119	
Holt	17%	0.83 [0.63-1.09]	cases	15,227 (all patients)		COVIDENCE UK
Cho	53%	0.47 [0.26-0.87]	death	case control		
Sallis	59%	0.41 [0.22-0.76]	death	11/3,118	170/6,984	
Christensen	63%	0.37 [0.16-0.85]	death	543 (n)	529 (n)	
Lobelo	20%	0.80 [0.66-0.97]	hosp.	2,121 (n)	1,648 (n)	
Latorre-Román	76%	0.24 [0.05-1.04]	hosp.	n/a	n/a	
Marcus	42%	0.58 [0.48-0.71]	symp. case	240/10,627	134/3,708	
Yuan	70%	0.30 [0.09-0.92]	severe case	3/61	26/103	
Brandenburg	-6%	1.06 [0.23-4.79]	hosp.	102 (n)	39 (n)	
Bielik	30%	0.70 [0.40-1.21]	mod. case	775 (n)	365 (n)	
af Geijerstam	50%	0.50 [0.31-0.81]	death	318,902 (n)	336,271 (n)	
Lee	74%	0.26 [0.07-0.99]	death	2/11,072	32/41,293	
Maltagliati	52%	0.48 [0.25-0.87]	hosp.	n/a	n/a	
Baynouna AlKetbi	98%	0.01 [0.00-0.44]	death	n/a	n/a	
Ahmadi	30%	0.70 [0.54-0.89]	death	160/232,613	112/95,221	
Nguyen	20%	0.80 [0.72-0.88]	symp. case	904/2,836	483/1,111	
Lin	47%	0.53 [0.12-2.33]	cases	n/a	n/a	
de Souza	34%	0.66 [0.43-0.99]	hosp.	49/611	42/327	
Ekblom-Bak	48%	0.52 [0.30-0.92]	severe case	n/a	n/a	
Lengelé	74%	0.26 [0.07-0.80]	cases	23/229	4/12	
Saadeh	9%	0.91 [0.56-1.43]	symp. case	362 (n)	225 (n)	
Hamrouni	29%	0.71 [0.55-0.92]	death	138/106,006	109/47,827	
Huang	66%	0.34 [0.17-0.70]	cases	n/a	n/a	
Hamdan	16%	0.84 [0.49-1.39]	hosp.	22/128	37/172	
Steenkamp	42%	0.58 [0.50-0.68]	death	29,469 (n)	13,366 (n)	
Gilley	-42%	1.42 [0.60-3.35]	cases	172/1,917	5/79	
Almansour	6%	0.94 [0.40-1.47]	cases	35/71	38/71	
Beydoun	43%	0.57 [0.32-1.01]	cases	1,710 (n)	448 (n)	
Salgado-Aranda	83%	0.17 [0.05-0.56]	death	4/223	41/297	
Paul	38%	0.62 [0.30-1.20]	PASC	1,811 (all patients)		LONG COVID
Malisoux	63%	0.37 [0.14-0.98]	progression	115 (n)	108 (n)	
Antunes	80%	0.20 [0.03-1.41]	ICU	1/14	9/25	
Tsuzuki	56%	0.44 [0.36-0.52]	severe case	3,340 (n)	1,528 (n)	
Reis	41%	0.59 [0.26-1.26]	hosp.	9/241	29/305	
Pływaczewska-J..	11%	0.89 [0.72-1.11]	m/s case	490 (n)	1,357 (n)	
Pitanga	33%	0.67 [0.45-1.01]	cases	1,469 (n)	1,552 (n)	
Green	42%	0.58 [0.53-0.63]	cases	1,267/11,144	16,198/101,931	
Kapusta	71%	0.29 [0.20-0.43]	severe case	181 (n)	387 (n)	
Young	74%	0.26 [0.20-0.33]	death	11,279 (n)	29,099 (n)	
Wang	11%	0.89 [0.75-1.06]	PASC	274/691	283/594	LONG COVID
Park	26%	0.74 [0.53-1.04]	death	n/a	n/a	
Sanchez	54%	0.46 [0.38-0.55]	symp. case	n/a	n/a	
Cardoso	73%	0.27 [0.17-0.45]	severe case	case control		
Feter	26%	0.74 [0.58-0.95]	PASC	52 (n)	95 (n)	LONG COVID
Sutkowska	62%	0.38 [0.08-1.72]	death	71 (n)	60 (n)	
Frish	53%	0.47 [0.23-0.95]	cases	212 (n)	1,202 (n)	
Schmidt	31%	0.69 [0.50-0.94]	cases	956 (n)	2,705 (n)	CoCo-Fakt
Šebić	89%	0.11 [0.01-0.96]	oxygen	0/53	4/47	
Akbar	7%	0.93 [0.79-1.10]	cases	3,333 (n)	3,333 (n)	
Pavlidou	42%	0.58 [0.51-0.68]	cases	902 (n)	4,295 (n)	
Wang	30%	0.70 [0.61-0.80]	death	57,930 (n)	10,966 (n)	
Muñoz-Vergara	27%	0.73 [0.60-0.90]	hosp.	332/42,159	203/12,405	
Prophylaxis	38%	0.62 [0.57-0.68]		3,934/1,145,941	18,178/771,665	38% lower risk
Tau^2 = 0.06, I^2 = 80.5%, p < 0.0001						
All studies	38%	0.62 [0.57-0.68]		3,950/1,146,142	18,240/771,903	38% lower risk

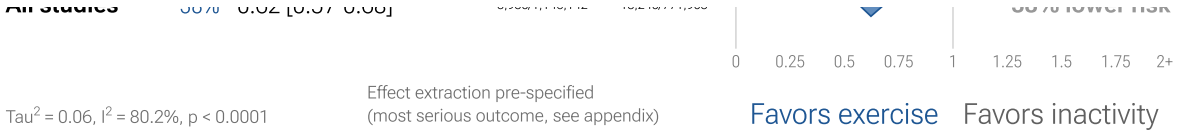


Figure 11. **Random effects meta-analysis for all studies after exclusions.** This plot shows pooled effects, see the specific outcome analyses for individual outcomes, and the heterogeneity section for discussion. Effect extraction is pre-specified, using the most serious outcome reported. For details of effect extraction see the appendix.

Conclusion

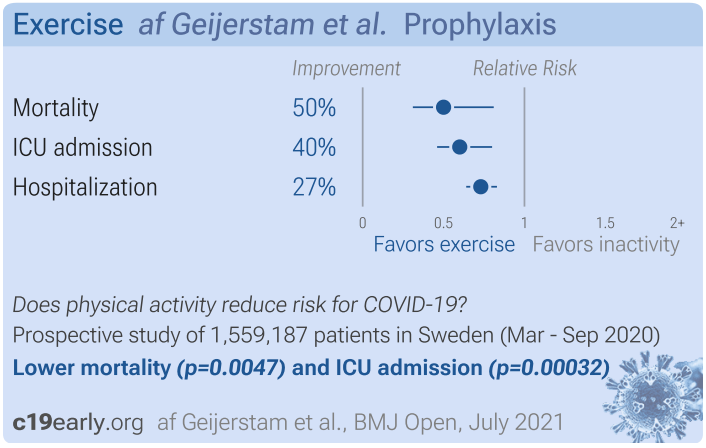
More physically active people have reduced risk for COVID-19. Statistically significant lower risk is seen for mortality, ventilation, ICU admission, hospitalization, progression, recovery, and cases. 51 studies from 51 independent teams in 24 countries show statistically significant improvements. Meta analysis using the most serious outcome reported shows 39% [34-44%] lower risk. Results are similar for higher quality and peer-reviewed studies. Results are robust — in exclusion sensitivity analysis 54 of 66 studies must be excluded to avoid finding statistically significant efficacy in pooled analysis. Results are consistent with the overall risk of all cause mortality based on cardiorespiratory fitness — *Laukkanen* show RR 0.55 [0.50-0.61] for the top vs. bottom tertiles.

Most studies analyze exercise/physical activity levels before infection, comparing regular/moderate exercise and lower/no exercise. Risk may increase with more extreme activity levels.

Other meta analyses show significant improvements with exercise for mortality *Ezzatvar, Halabchi, Liu, Rahmati, Sittichai*, ICU admission *Rahmati*, hospitalization *Ezzatvar, Halabchi, Li, Rahmati*, severity *Ezzatvar, Liu, Sittichai*, and cases *Ezzatvar*.

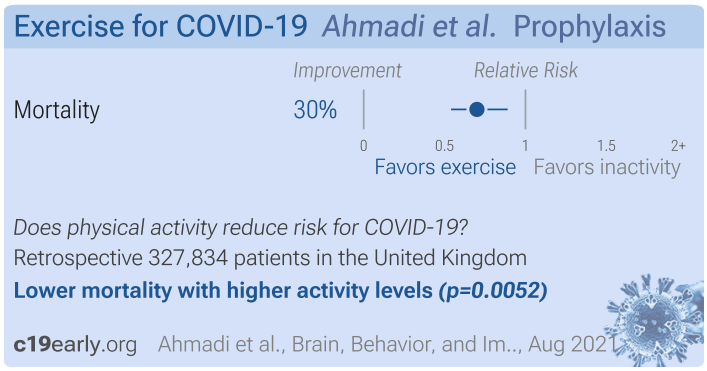
Study Notes

af Geijerstam



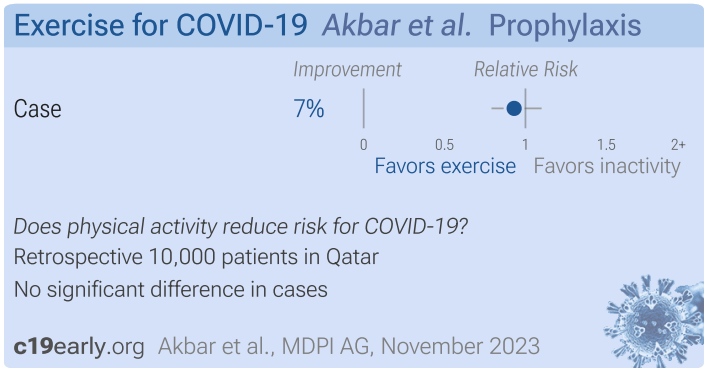
af Geijerstam: Prospective study of 1,559,187 men in Sweden with cardiorespiratory fitness levels measured on military conscription, showing high cardiorespiratory fitness associated with lower risk of COVID-19 hospitalization, ICU admission, and death.

Ahmadi



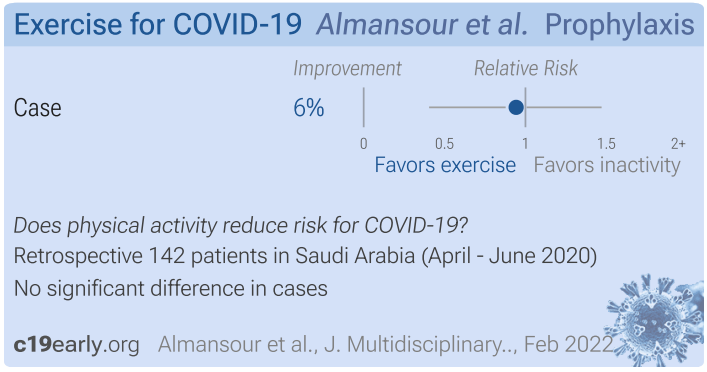
Ahmadi: Retrospective 468,569 adults in the UK, showing no significant difference in COVID-19 mortality based on diet quality, however significantly lower mortality was seen with higher diet quality for pneumonia and infectious diseases.

Akbar



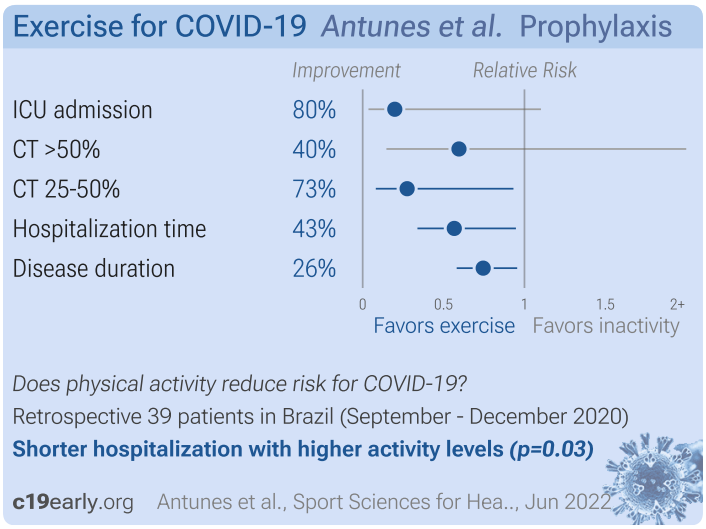
Akbar: Retrospective 10,000 adults in Qatar, showing lower risk of COVID-19 cases with increased leisure time physical activity, without statistical significance. Authors do not analyze COVID-19 severity.

Almansour



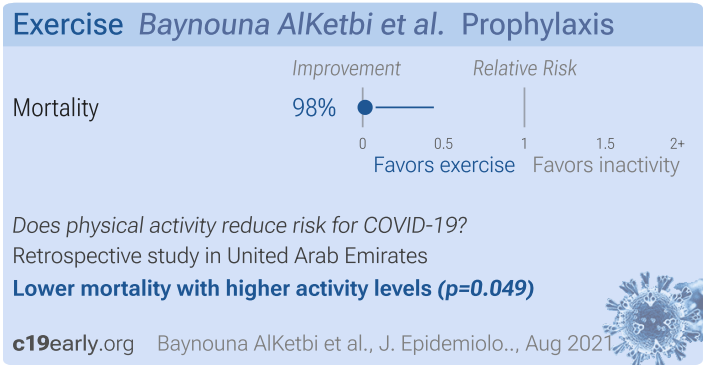
Almansour: Retrospective 142 patients in Saudi Arabia, showing no significant difference in cases with physical activity.

Antunes



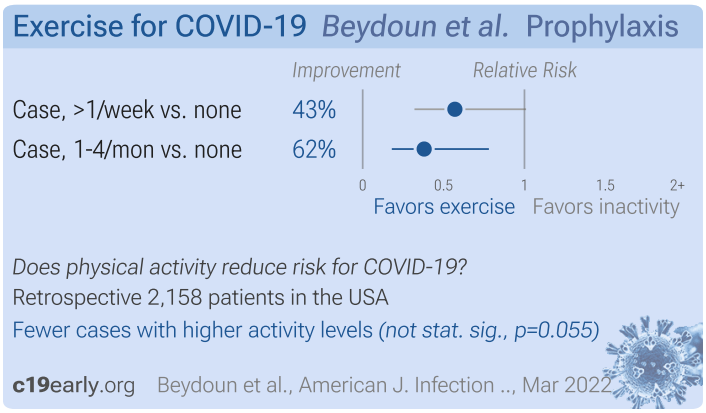
Antunes: Retrospective 39 hospitalized COVID-19 survivors >60 years old, showing shorter hospitalization for patients with active lifestyles before COVID-19 symptoms.

Baynouna AlKetbi



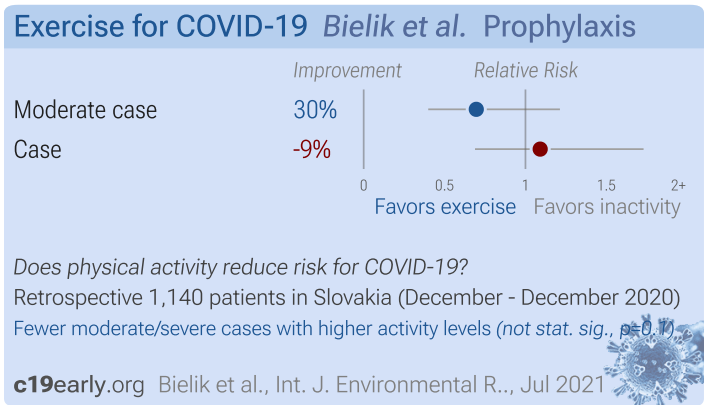
Baynouna AlKetbi: Retrospective 234 COVID-19 cases in the United Arab Emirates, showing lower risk of mortality with increased physical activity.

Beydoun



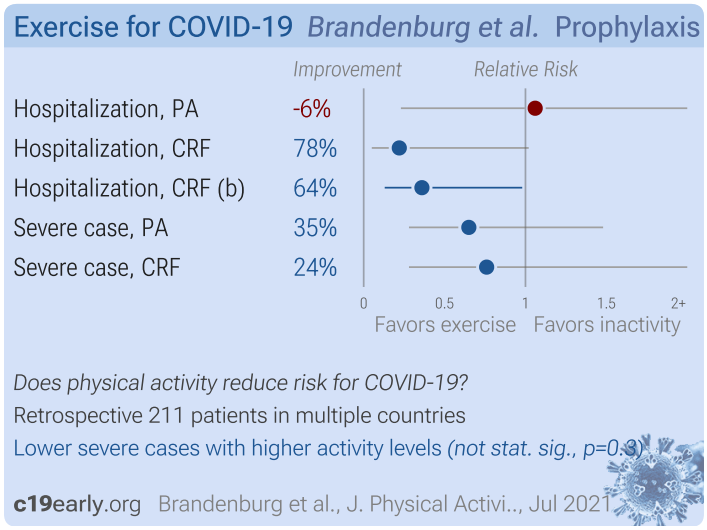
Beydoun: Retrospective 2,830 people in the USA, showing lower risk of COVID-19 with a history of moderate/vigorous exercise.

Bielik



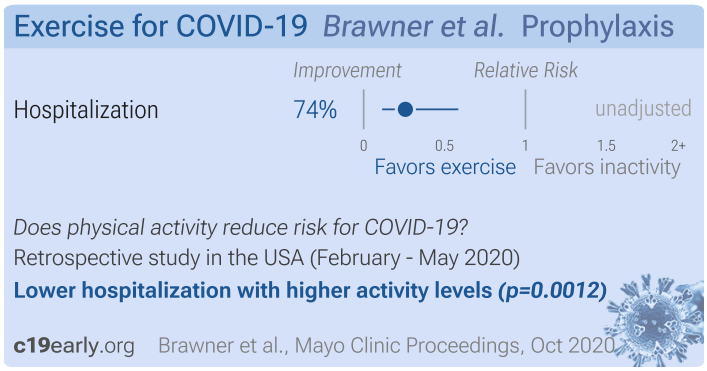
Bielik: Retrospective 1,544 participants in Slovakia, showing a lower risk of more severe COVID-19 for physically active participants, without statistical significance.

Brandenburg



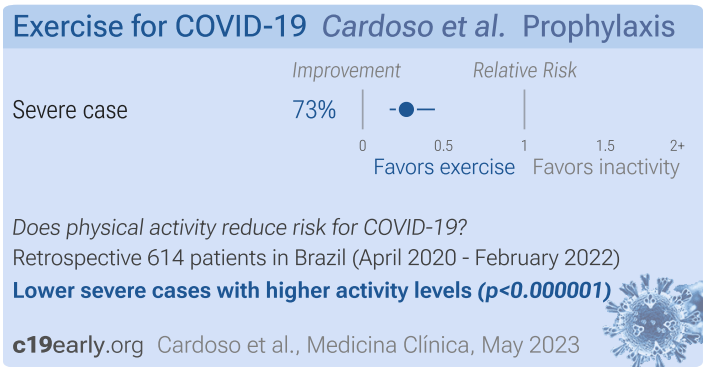
Brandenburg: Retrospective 263 COVID+ patients, showing lower hospitalization with higher self-reported cardiorespiratory fitness, but no significant differences for physical activity. Participants in the study were healthier and more fit than the general population.

Brawner



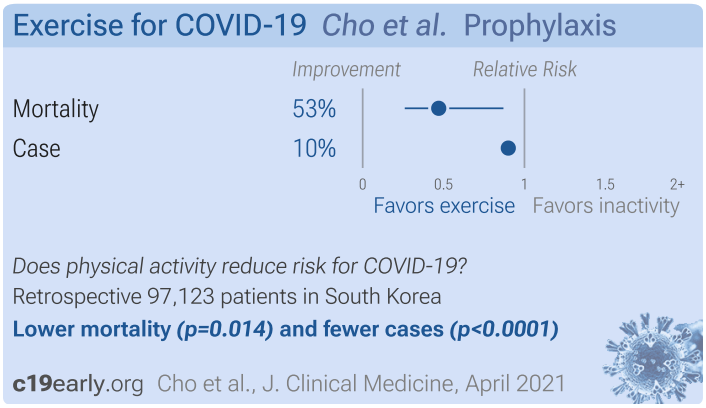
Brawner: Retrospective 246 COVID-19 patients in the USA, showing the risk of hospitalization inversely associated with maximal exercise capacity. Adjusted results are only provided for MET as a continuous variable.

Cardoso



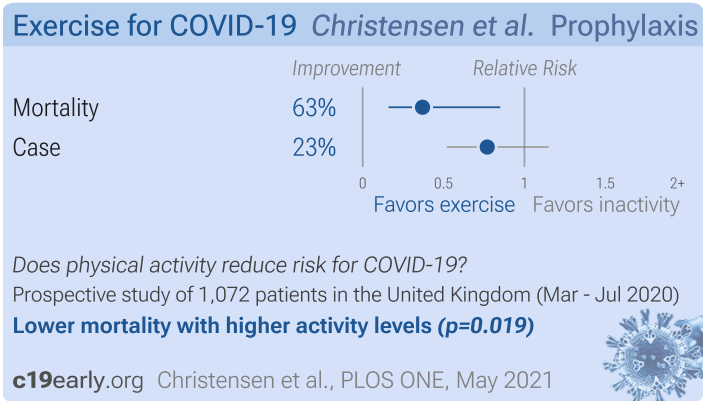
Cardoso: Case control study with 307 severe COVID-19 ICU patients and 307 matched COVID-19 outpatients in Brazil, showing significantly higher risk of severe cases with low physical activity.

Cho



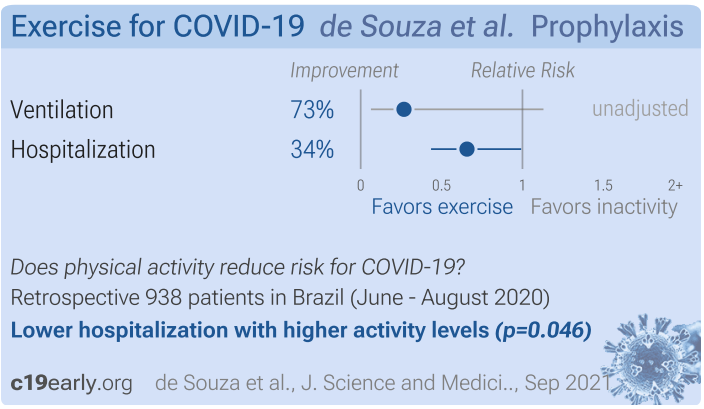
Cho: Retrospective 6,288 COVID+ patients and 125,772 matched controls in South Korea, showing significantly lower risk of COVID-19 infection and mortality with higher physical activity.

Christensen



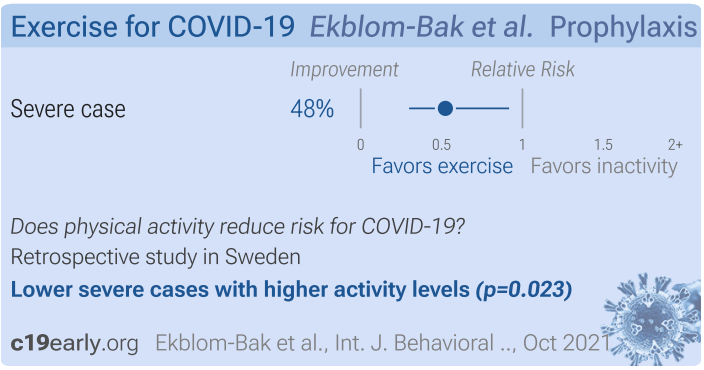
Christensen: Prospective study of 2,690 adults in the UK Biobank showing lower cardiorespiritory fitness associated with COVID-19 mortality.

de Souza



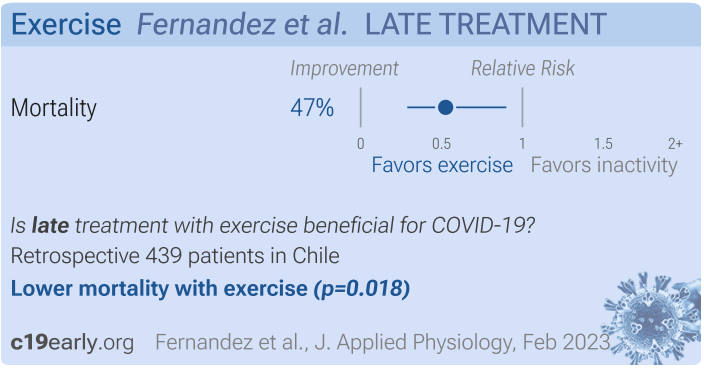
de Souza: Retrospective survey of 938 COVID-19 recovered patients in Brazil, showing lower hospitalization with physical activity. NCT04396353.

Ekblom-Bak



Ekblom-Bak: Retrospective 857 severe COVID-19 cases and matched controls in Sweden, showing lower risk of severe COVID-19 with higher cardiorespiratory fitness.

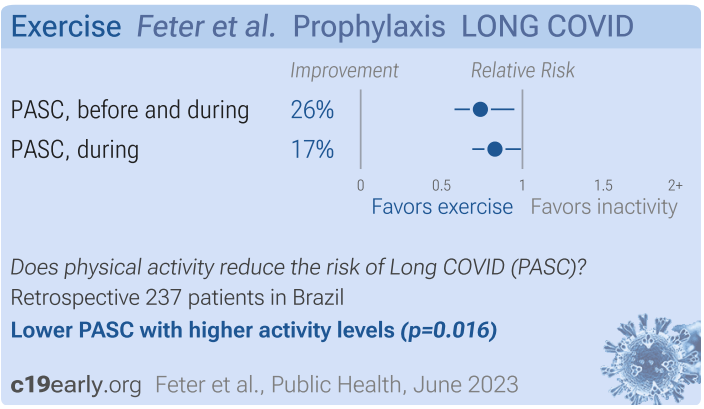
Fernandez



Fernandez: Retrospective 439 severe COVID-19 hospitalized patients with hypertension, 201 receiving a supervised exercise program, showing significantly lower mortality with exercise. Exercise included of aerobic, breathing, and musculoskeletal exercises, 3 to 4 times per week. There were significantly more control patients on beta-adrenergic blockers and thiazide diuretics.

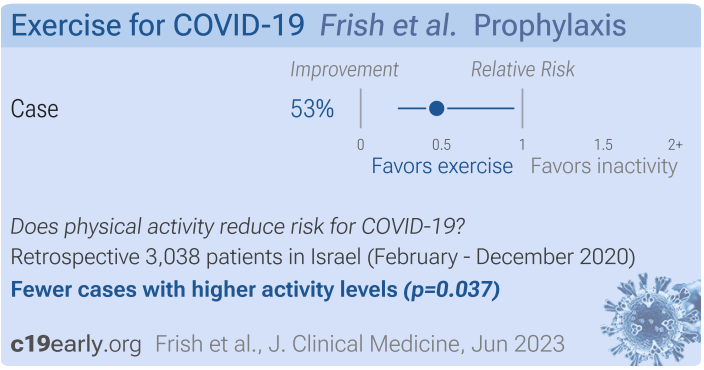
There are many possible mechanisms of action, including improved circulation, stress reduction, hormone regulation, improved sleep, increased antioxidant levels, and increased nitric oxide levels in the respiratory system. Over-exercising may be detrimental and lead to impaired immune function.

Feter



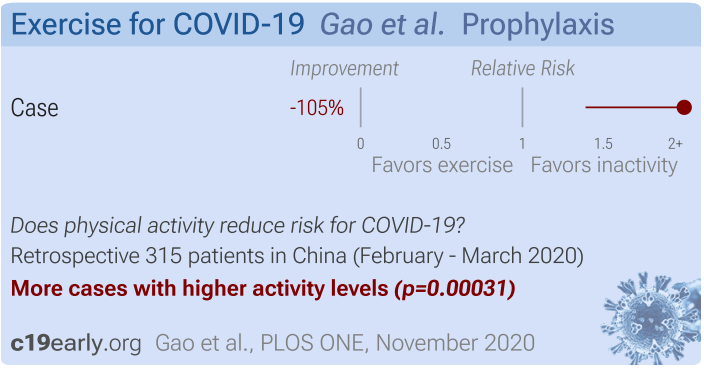
Feter: Analysis of 237 COVID-19 patients in Brazil, showing lower risk of long COVID with physical activity.

Frish



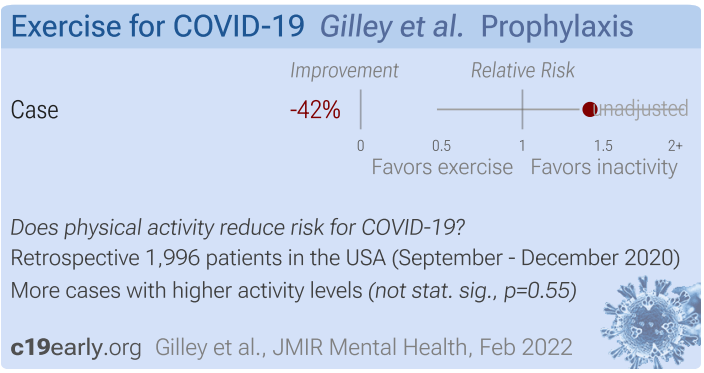
Frish: Retrospective 3,038 bariatric surgery patients in Israel, showing higher risk of SARS-CoV-2 infection with vitamin D deficiency, and lower risk with physical activity.

Gao



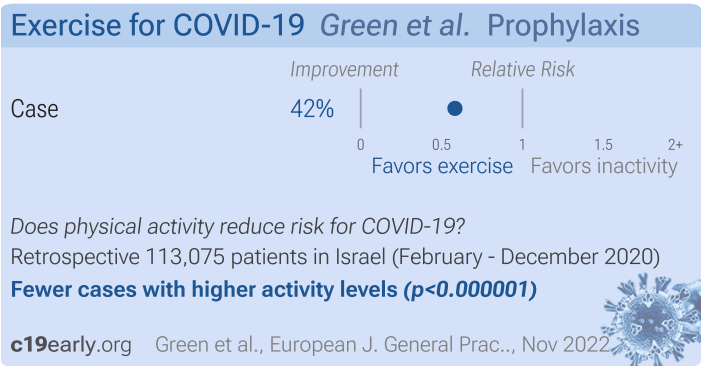
Gao: Case control study in China with 105 cases and 210 matched controls, showing COVID-19 cases associated with physical activity ≥5 times per week. Authors note that people may choose gyms for exercise in winter, leading to higher exposure risk.

Gilley



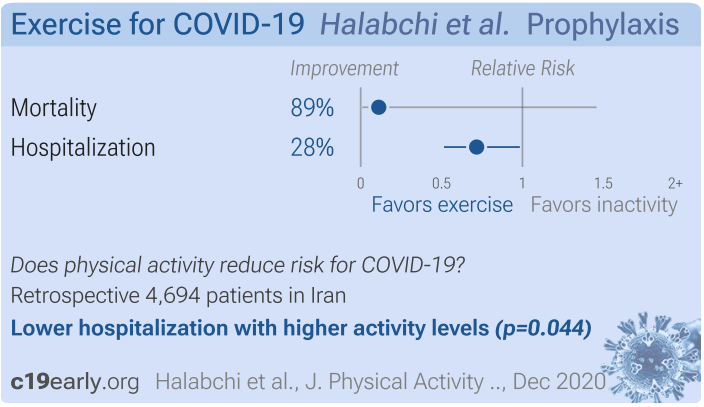
Gilley: Retrospective survey of 1,997 college students in the USA, showing no significant difference in COVID-19 cases with exercise in unadjusted results.

Green



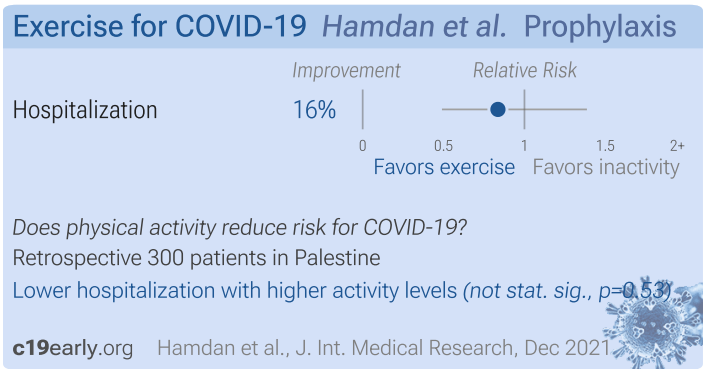
Green: Retrospective 113,075 people in Israel, showing lower risk of COVID-19 cases with physical activity and a dose dependent response.

Halabchi



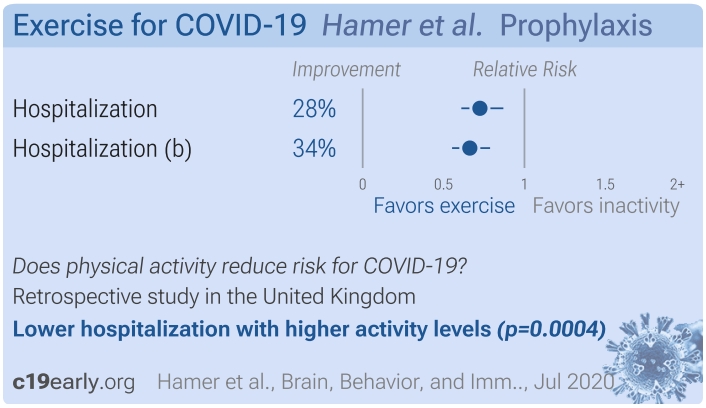
Halabchi (B): Retrospective 4,694 COVID-19 patients in Iran, showing lower risk of hospitalization and mortality with regular sports participation.

Hamdan



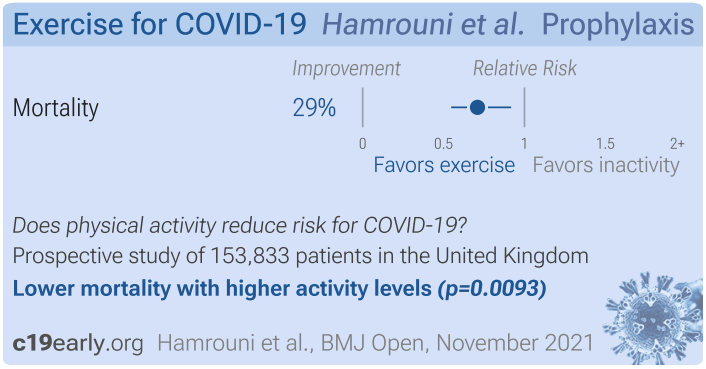
Hamdan: Retrospective 300 participants in Palestine, showing lower risk of hospitalization with physical activity, without statistical significance.

Hamer



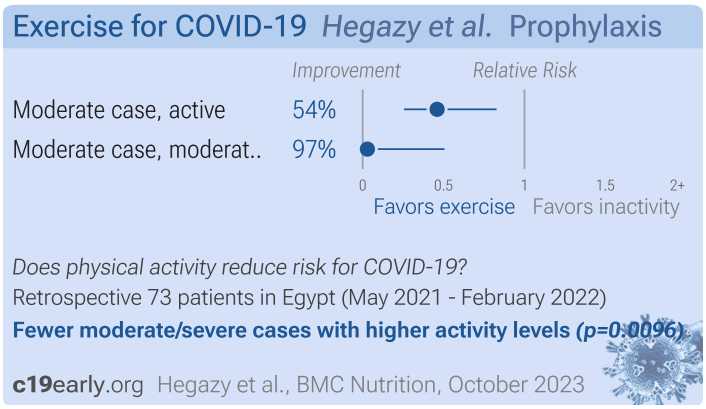
Hamer: UK Biobank retrospective analysis of 387,109 people, showing lower risk of COVID-19 hospitalization with physical activity.

Hamrouni



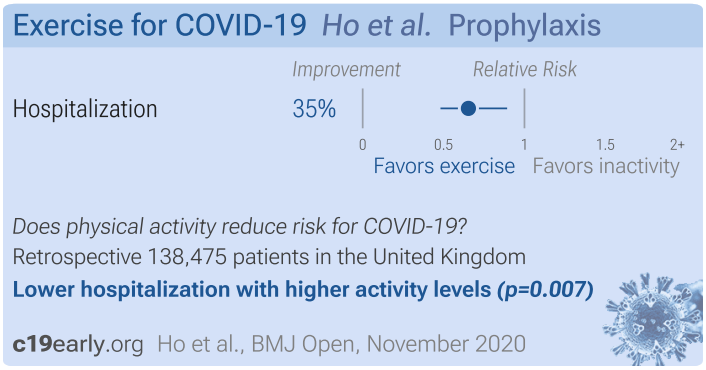
Hamrouni: Prospective UK Biobank analysis, showing a history of low physical activity associated with COVID-19 mortality.

Hegazy



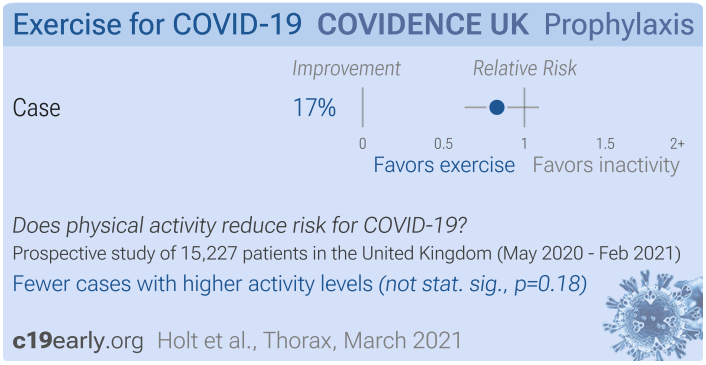
Hegazy: Retrospective 68 COVID-19 patients showing physical activity and healthier nutrition associated with lower COVID-19 severity.

Ho



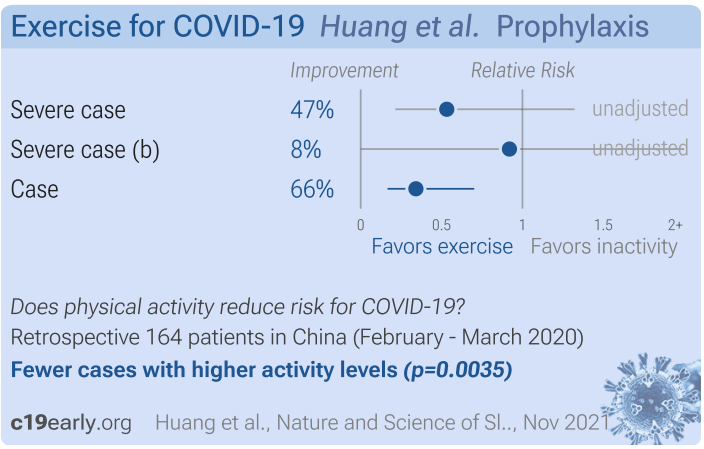
Ho: UK Biobank retrospective 235,928 participants using walking pace as a proxy for physical fitness, showing lower risk of COVID-19 hospitalization with an average vs. slow walking pace.

Holt



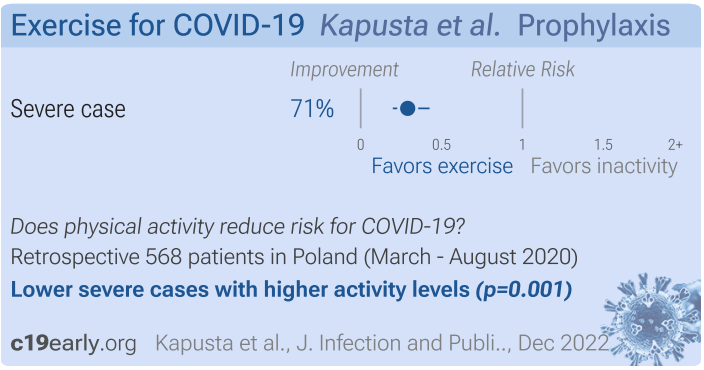
Holt: Prospective survey-based study with 15,227 people in the UK, showing reduced risk of COVID-19 cases with lower impact physical activity. NCT04330599. COVIDENCE UK.

Huang



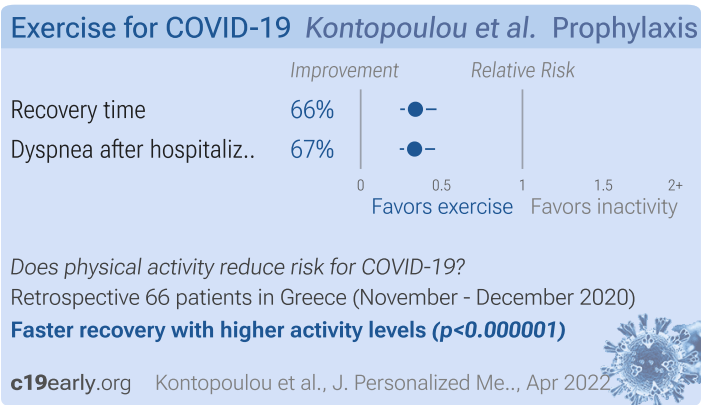
Huang: Retrospective 164 COVID-19 patients and 188 controls in China, showing lower risk of cases with regular exercise.

Kapusta



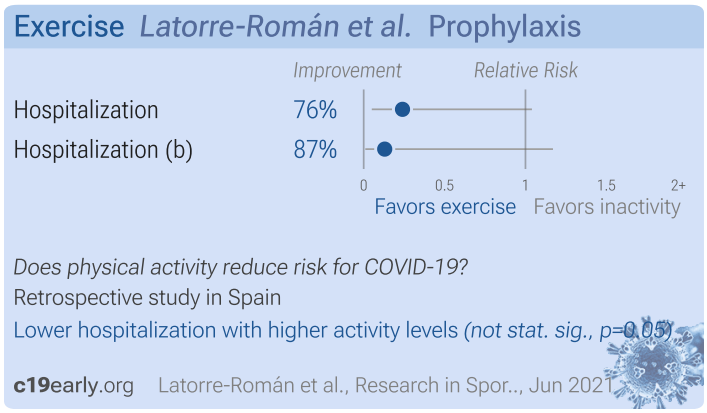
Kapusta: Retrospective 568 convalescent COVID-19 patients in Poland, showing lower risk of severe cases with regular physical activity in the 3 months before COVID-19.

Kontopoulou



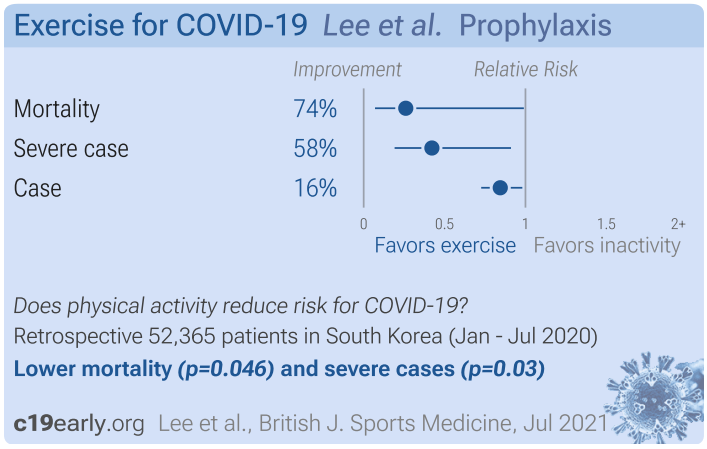
Kontopoulou: Retrospective 66 hospitalized COVID-19 patients in Greece, showing significantly improved recovery with a history of exercise in unadjusted results. Exercise after hospitalization was also associated with lower levels of dyspnea one month post hospitalization.

Latorre-Román



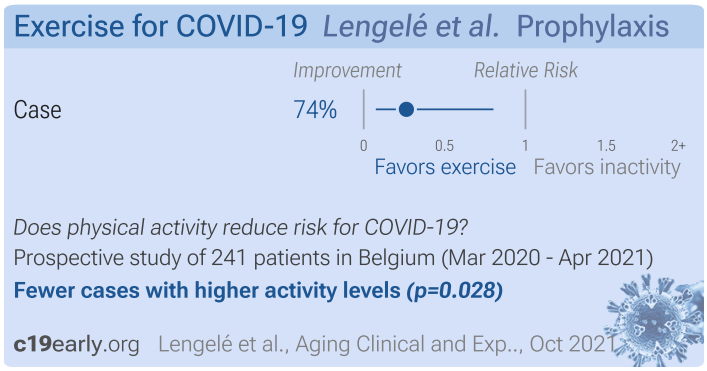
Latorre-Román: Retrospective 420 people in Spain, showing lower risk of COVID-19 hospitalization with a history of physical activity.

Lee



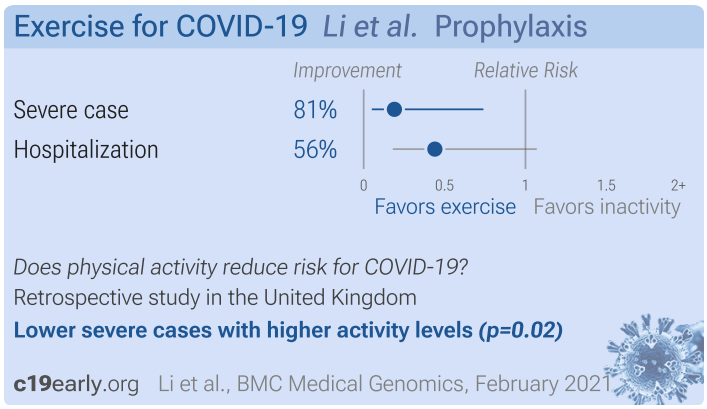
Lee: Retrospective 212,768 adults in South Korea, showing lower risk of COVID-19 cases, severity, and mortality with physical activity. Notably, results for aerobic and muscle strengthening activities combined were much better than results for either one in isolation.

Lengelé



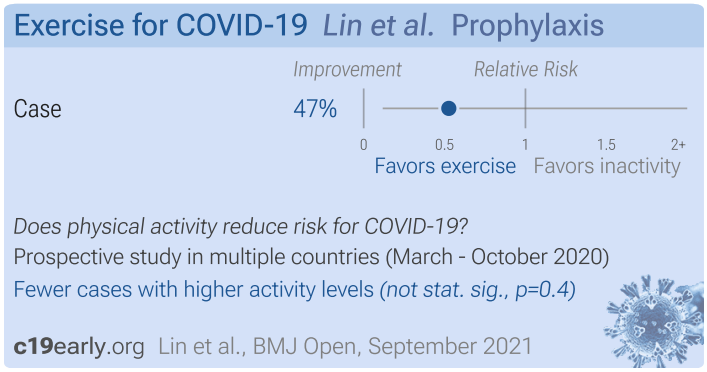
Lengelé: Analysis of 241 adults >65yo in Belgium, showing lower risk of COVID-19 with a history of physical activity.

Li



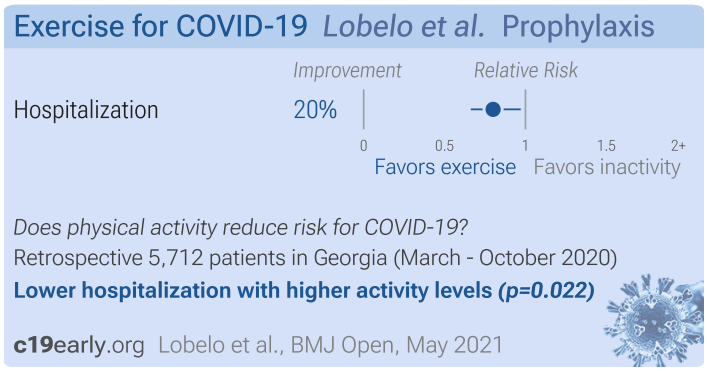
Li (B): Mendelian randomization study showing lower risk of severe COVID-19 with physical activity.

Lin



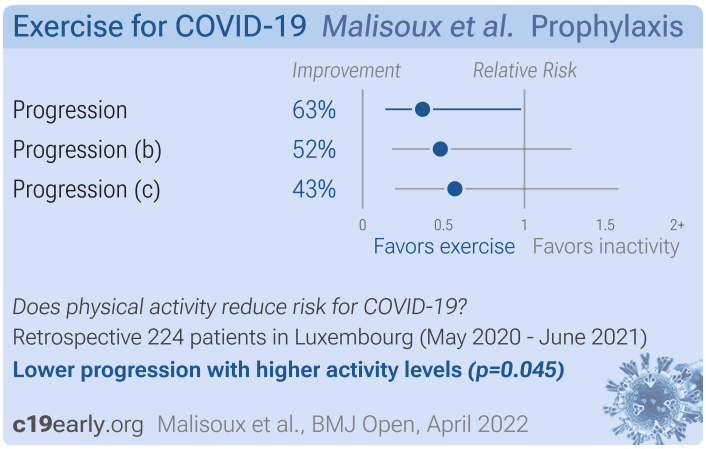
Lin: Prospective survey analysis of 28,575 people in 99 countries, showing a lower risk of COVID-19 with a exercise, without statistical significance.

Lobelo



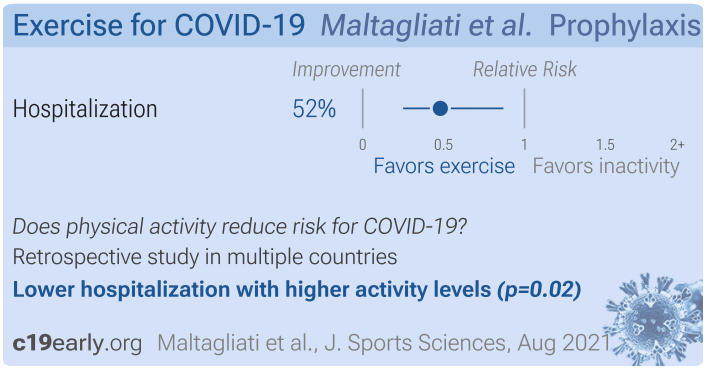
Lobelo: Retrospective 5,712 COVID-19 patients in the USA, showing higher risk of COVID-19 hospitalization with a history of physical inactivity.

Malisoux



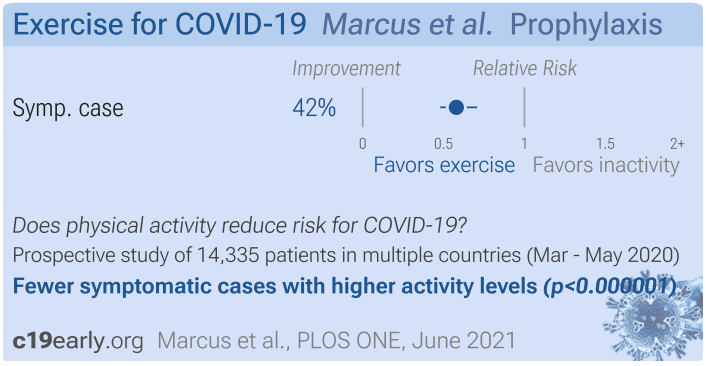
Malisoux: Retrospective 452 participants in Luxembourg, showing lower risk of moderate cases with higher physical activity.

Maltagliati



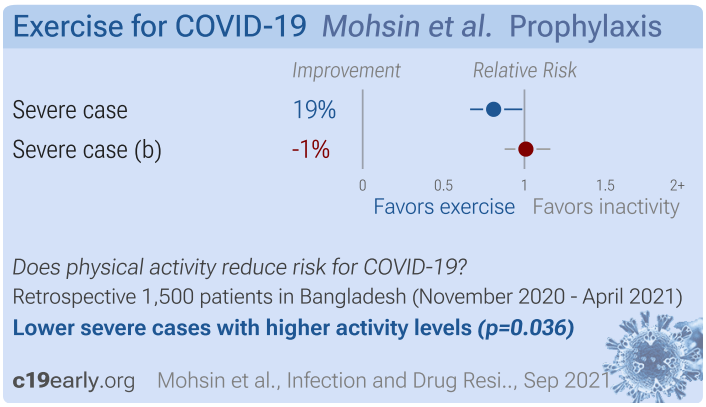
Maltagliati: Retrospective 3,139 adults >50 in Europe, with 66 COVID-19 hospitalizations, showing lower risk of hospitalization with higher physical activity and with higher muscle strength. Note that model 2 includes muscle strength which is correlated with physical activity *eurapa.biomedcentral.com*.

Marcus



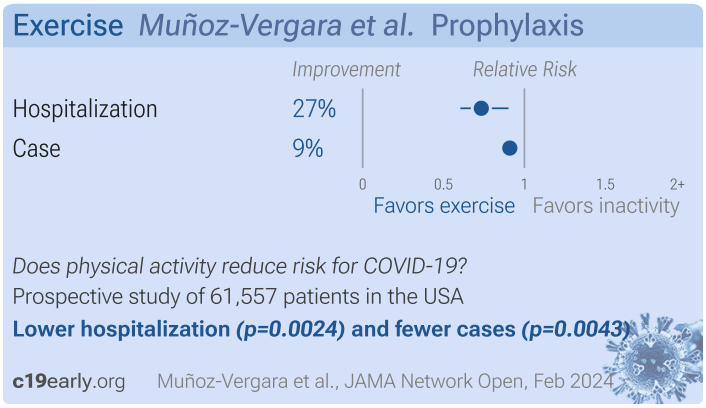
Marcus: Prospective survey based study with 14,335 participants, showing lower risk of viral symptoms with regular exercise.

Mohsin



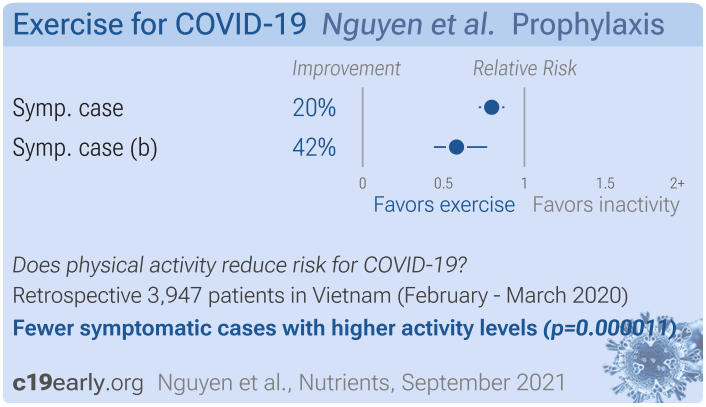
Mohsin: Retrospective 1,500 COVID+ patients in Bangladesh, showing lower risk of severe cases with regular exercise in unadjusted results.

Muñoz-Vergara



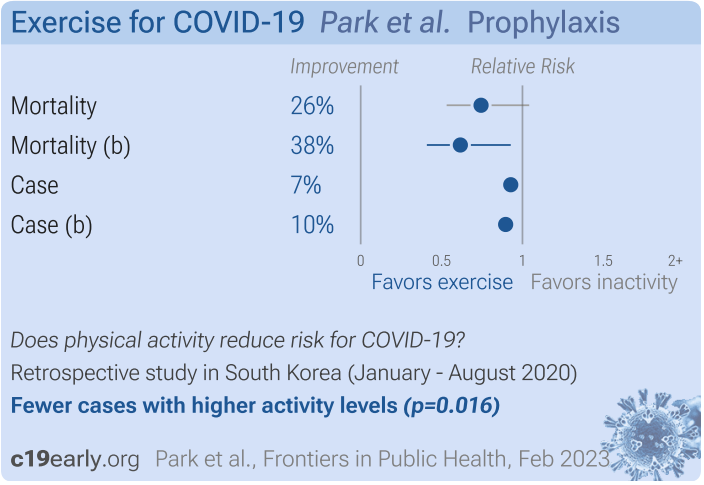
Muñoz-Vergara: Prospective study of 61,557 adults aged 45+ years showing reduced risk of COVID-19 diagnosis and hospitalization for those meeting physical activity guidelines of ≥7.5 MET-hours/week before the pandemic compared to inactive individuals.

Nguyen



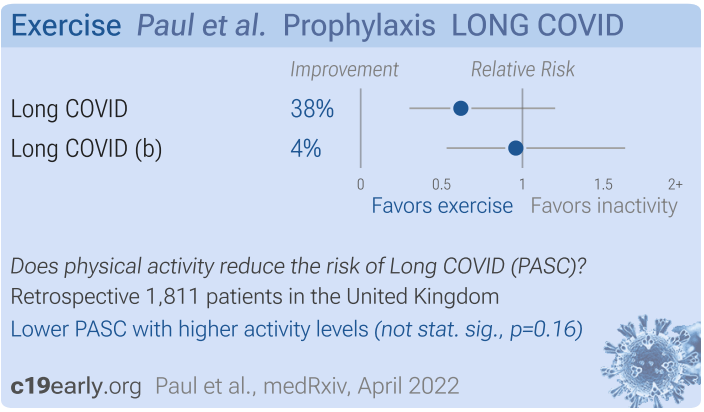
Nguyen: Analysis of 3,947 participants in Vietnam, showing significantly lower risk of COVID-19-like symptoms with physical activity and with a healthy diet. The combination of being physically active and eating healthy reduced risk further compared to either alone. The analyzed period was Feb 14 to Mar 2, 2020, which may have been before testing was widely available.

Park



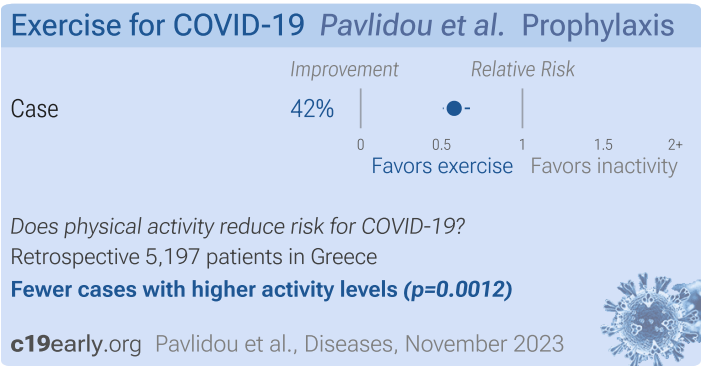
Park: Retrospective 4,363 COVID-19 patients and 67,125 controls in South Korea, showing higher risk of mortality and cases with insufficient physical activity.

Paul



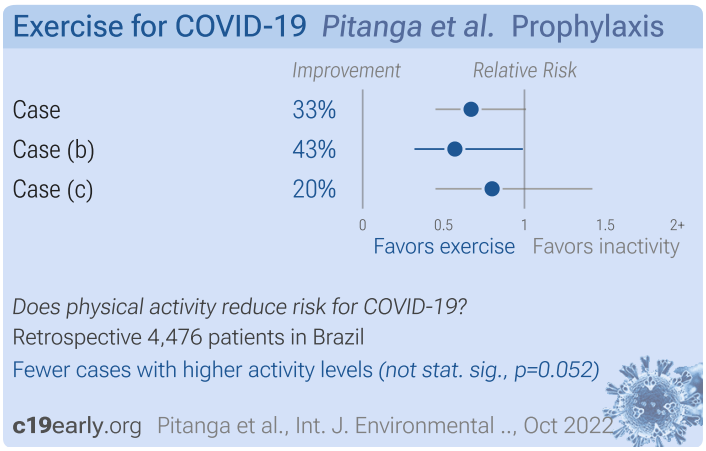
Paul: Retrospective 1,811 COVID-19 patients in the UK, showing lower risk of self-reported long COVID with 3+ hours of exercise per week in the month before infection, without statistical significance (p=0.16).

Pavlidou



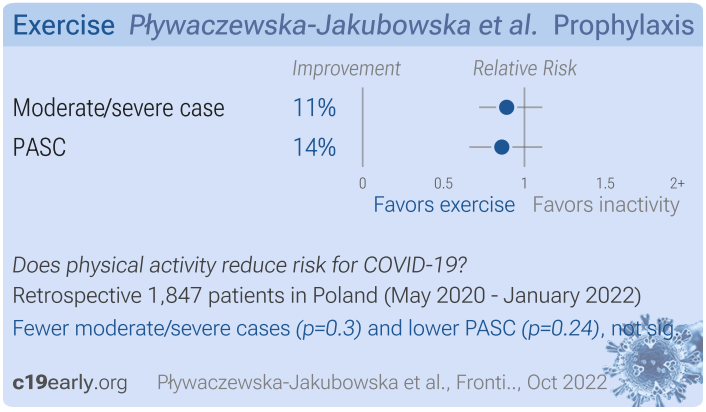
Pavlidou: Retrospective 5,197 Greek adults over 65. After adjustment for confounders, COVID-19 infection was independently associated with poor sleep, low physical activity, low Mediterranean diet adherence, living in urban areas, smoking, obesity, depression, anxiety, stress, and poor health-related quality of life.

Pitanga



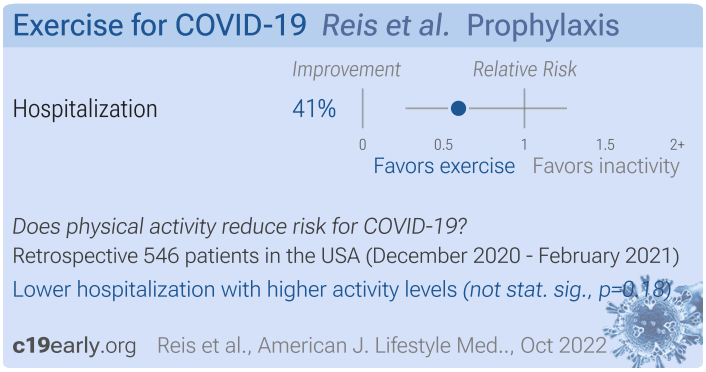
Pitanga: Retrospective 4,476 participants in Brazil, showing lower risk of COVID-19 cases with a history of physical activity, statistically significant only for those following specific practices to protect against COVID-19.

Pływaczewska-Jakubowska



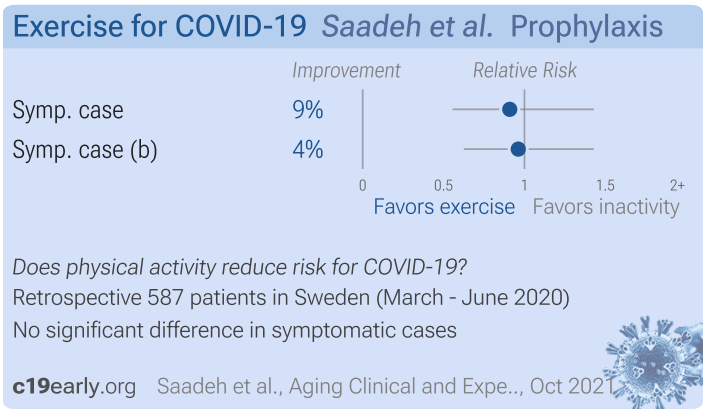
Pływaczewska-Jakubowska: Retrospective 1,847 COVID+ patients in Poland, showing no significant difference in moderate/severe cases with physical activity. Hospitalized patients were excluded.

Reis



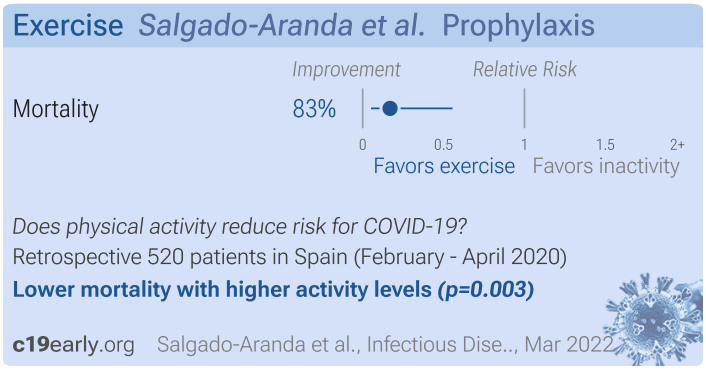
Reis: Retrospective 546 COVID+ patients in the USA, showing lower risk of hospitalization with higher frequency of strength training, without statistical significance.

Saadeh



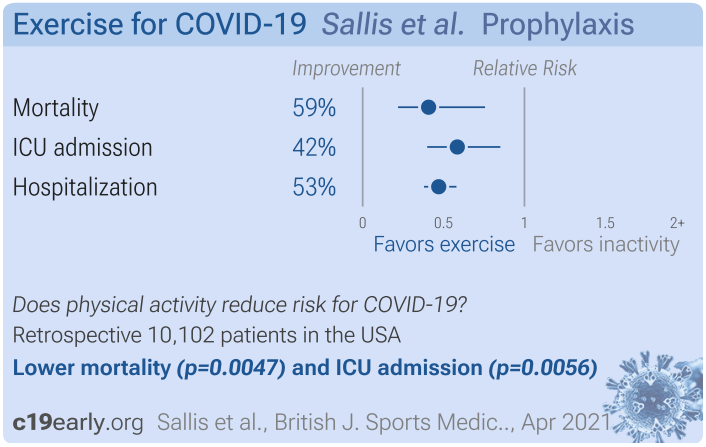
Saadeh: Retrospective 904 patients in Sweden, showing higher risk of COVID-19-like symptoms with poor muscle strength. Risk was slightly higher for physical inactivity, without statistical significance.

Salgado-Aranda



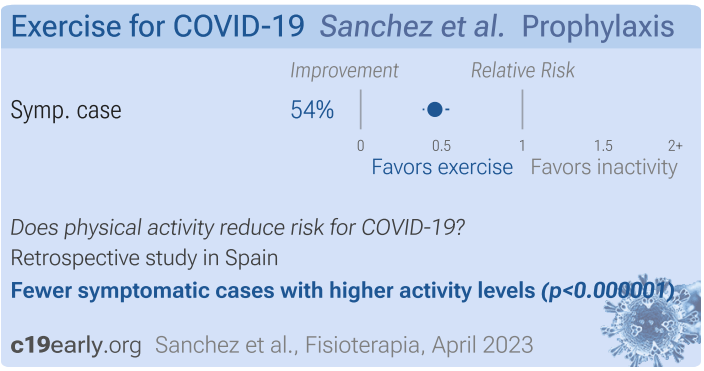
Salgado-Aranda: Retrospective 520 COVID-19 patients in Spain, showing significantly lower mortality with a history of physical activity.

Sallis



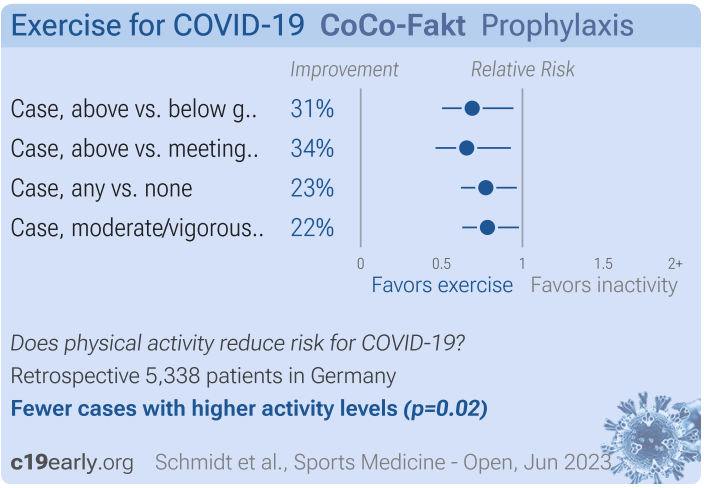
Sallis: Retrospective 48,440 COVID-19 patients in the USA, showing significantly lower mortality, ICU admission, and hospitalization with exercise.

Sanchez



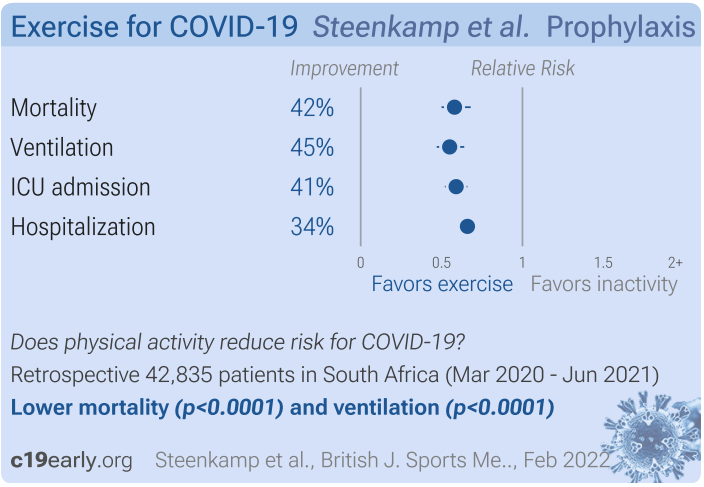
Sanchez: Retrospective 29,875 university staff and students in Spain, 3,662 with data, showing lower risk of COVID-19 symptoms for people that exercise. Exercise more than 5 days/week was the most protective, and intense exercise was more effective than moderate exercise.

Schmidt



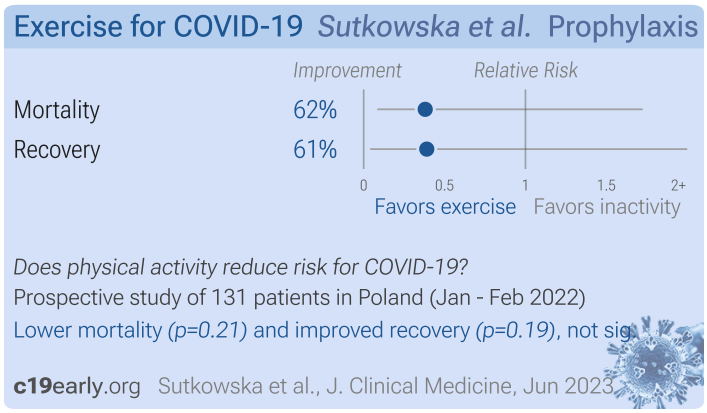
Schmidt: Retrospective 5,338 individuals with confirmed contact with a COVID-19 patient, showing lower risk of COVID-19 with exercise.

Steenkamp



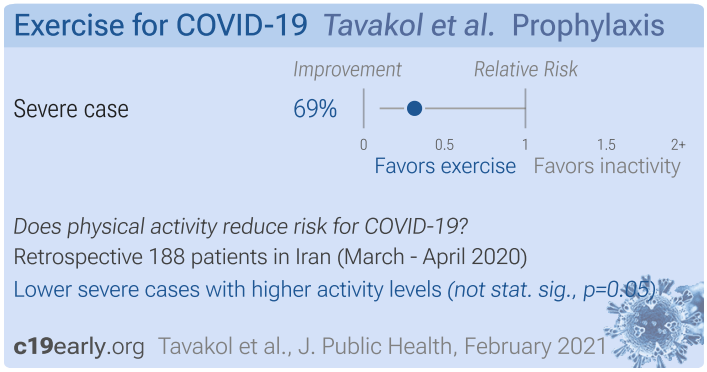
Steenkamp: Retrospective 65,361 COVID-19 patients in South Africa, showing significantly lower hospitalization, ICU admission, ventilation, and mortality with exercise.

Sutkowska



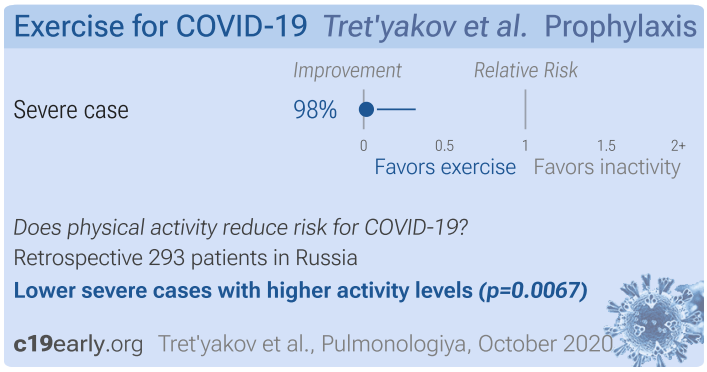
Sutkowska: Prospective study of 131 hospitalized patients in Poland, showing lower mortality and improved recovery with a history of higher physical activity.

Tavakol



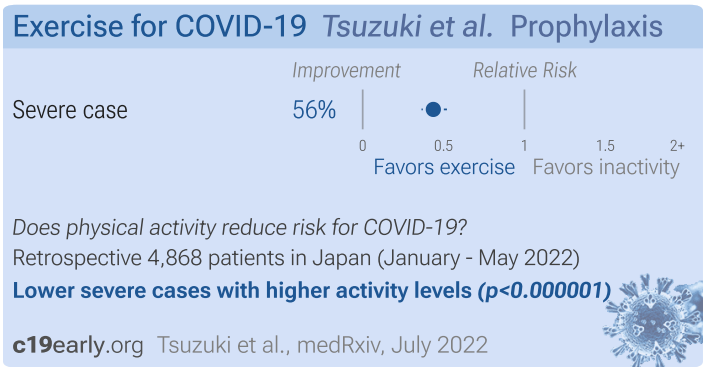
Tavakol: Retrospective 206 patients in Iran, showing COVID-19 disease severity associated with lower physical activity.

Tret'yakov



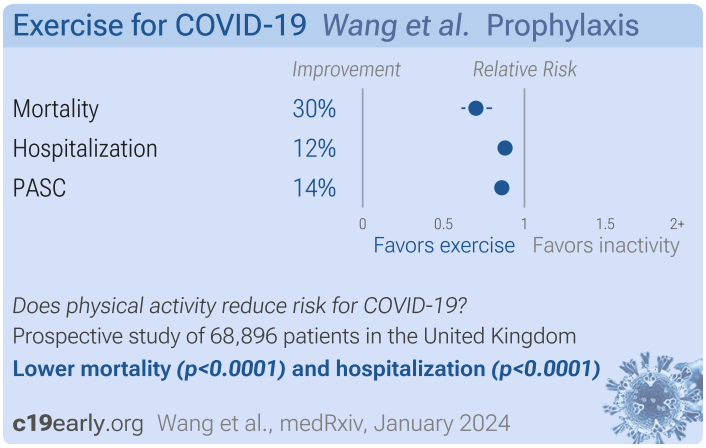
Tret'yakov: Retrospective 293 COVID+ patients in Russia, showing lower risk of severe COVID-19 for individuals who regularly practice aerobic training in unadjusted results.

Tsuzuki



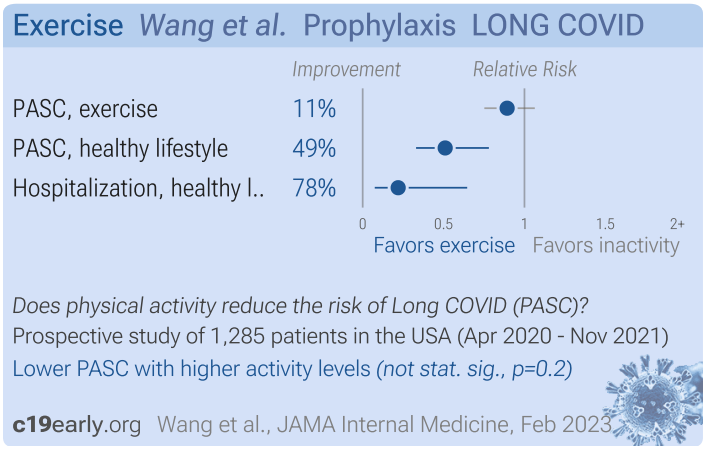
Tsuzuki: Retrospective 4,868 elderly COVID-19 patients in Japan, showing higher risk of severe cases with poor physical activity status.

Wang



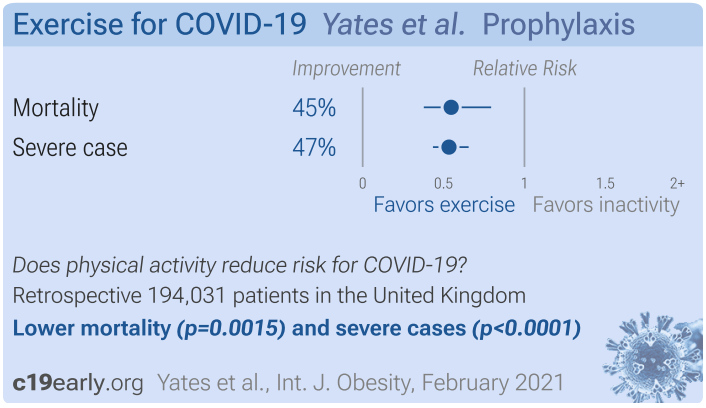
Wang: Prospective study of 68,896 UK Biobank participants with COVID-19 showing adherence to a healthy lifestyle prior to infection, characterized by 10 factors including adequate physical activity and sleep, not smoking, and a healthy BMI, was associated with a significantly lower risk of mortality, hospitalization, and post-COVID multisystem sequelae. Risk decreased monotonically for increasing numbers of healthy lifestyle factors from 5-10. Reduced risks were evident across cardiovascular, metabolic, neurologic, respiratory, and other disorders over 210 days following infection, during both acute and post-acute phases, regardless of age, sex, ethnicity, test setting, vaccination status, or SARS-CoV-2 variant.

Wang



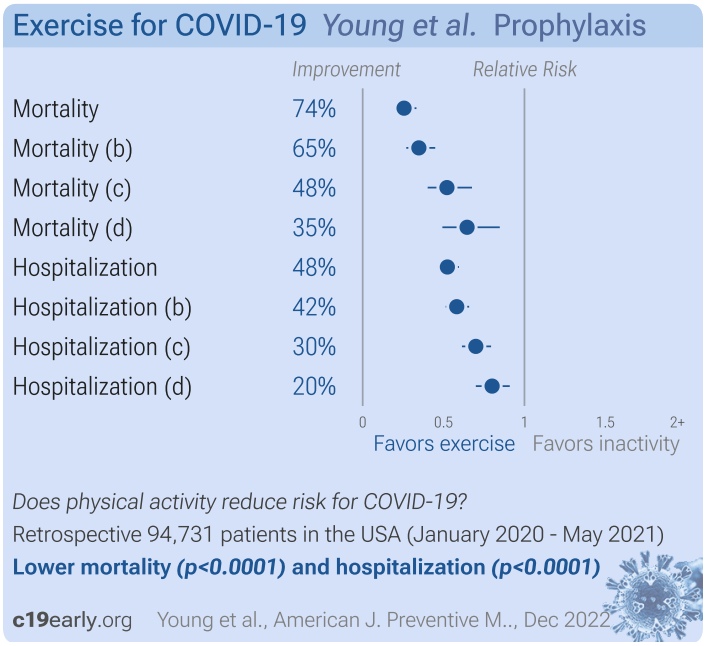
Wang (B): Prospective analysis of 32,249 women, showing lower risk of PASC with a healthy lifestyle, in a dose-dependent manner. Participants with 5 or 6 healthy lifestyle factors had significantly lower COVID-19 hospitalization and PASC. BMI and sleep were independently associated with risk of PASC.

Yates



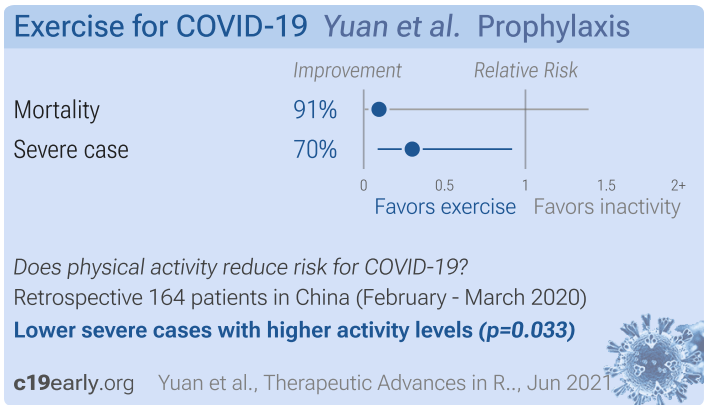
Yates: UK Biobank retrospective 412,596 people, showing severe COVID-19 and COVID-19 mortality inversely associated with self-reported walking pace.

Young



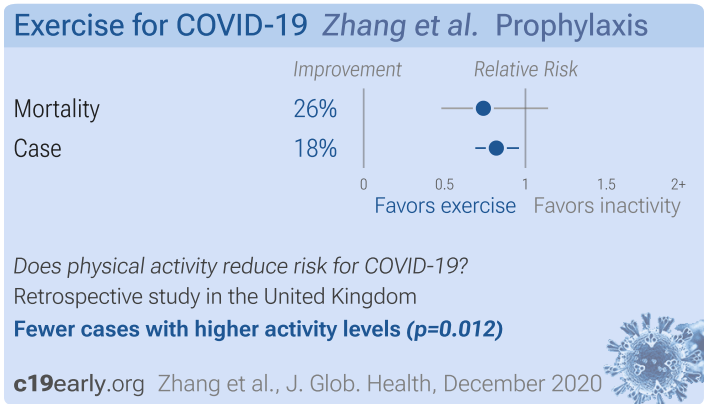
Young: Retrospective 194,191 COVID-19 patients in the USA, showing lower risk of hospitalization and mortality with physical activity, with a dose response relationship.

Yuan



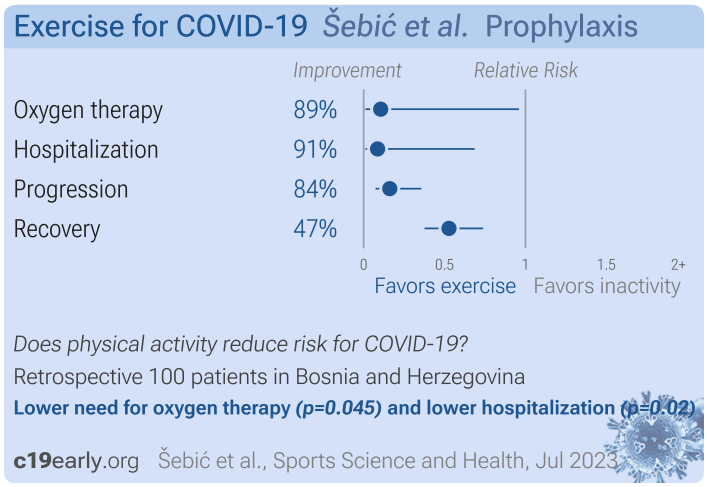
Yuan: Retrospective 164 COVID-19 patients in China, showing physical inactivity associated with an increased risk of severe COVID-19.

Zhang



Zhang (B): UK Biobank retrospective showing significantly lower COVID-19 cases with objectively measured physical activity.

Šebić



Šebić: Retrospective 100 COVID-19 patients in Bosnia and Herzegovina, showing lower symptom severity and faster recovery with a history of regular physical activity.

Appendix 1. Methods and Data

We perform ongoing searches of PubMed, medRxiv, Europe PMC, ClinicalTrials.gov, The Cochrane Library, Google Scholar, Research Square, ScienceDirect, Oxford University Press, the reference lists of other studies and meta-analyses, and submissions to the site c19early.org. Search terms are (exercise OR "physical activity") AND COVID-19. Automated searches are performed twice daily, with all matches reviewed for inclusion. All studies regarding the use of exercise for COVID-19 that report a comparison with a control group are included in the main analysis. Sensitivity analysis is performed, excluding studies with major issues, epidemiological studies, and studies with minimal available information. This is a living analysis and is updated regularly.

We extracted effect sizes and associated data from all studies. If studies report multiple kinds of effects then the most serious outcome is used in pooled analysis, while other outcomes are included in the outcome specific analyses. For example, if effects for mortality and cases are both reported, the effect for mortality is used, this may be different to the effect that a study focused on. If symptomatic results are reported at multiple times, we used the latest time, for example if mortality results are provided at 14 days and 28 days, the results at 28 days have preference. Mortality alone is preferred over combined outcomes. Outcomes with zero events in both arms are not used, the next most serious outcome with one or more events is used. For example, in low-risk populations with no mortality, a reduction in mortality with treatment is not possible, however a reduction in hospitalization, for example, is still valuable. Clinical outcomes are considered more important than viral test status. When basically all patients recover in both treatment and control groups, preference for viral clearance and recovery is given to results mid-recovery where available. After most or all patients have recovered there is little or no room for an effective treatment to do better, however faster recovery is valuable. If only individual symptom data is available, the most serious symptom has priority, for example difficulty breathing or low SpO_2 is more important than cough. When results provide an odds ratio, we compute the relative risk when possible, or convert to a relative risk according to *Zhang*. Reported confidence intervals and *p*-values were used when available, using adjusted values when provided. If multiple types of adjustments are reported propensity score matching and multivariable regression has preference over propensity score matching or weighting, which has preference over multivariable regression. Adjusted results have preference over unadjusted results for a more serious outcome when the adjustments significantly alter results. When needed, conversion between reported *p*-values and confidence intervals followed *Altman, Altman (B)*, and Fisher's exact test was used to calculate *p*-values for event data. If continuity correction for zero values is required, we use the reciprocal of the opposite arm with the sum of the correction factors equal to 1 *Sweeting*. Results are expressed with RR < 1.0 favoring treatment, and using the risk of a negative outcome when applicable (for example, the risk of death rather than the risk of survival). If studies only report relative continuous values such as relative times, the ratio of the time for the treatment group versus the time for the control group is used. Calculations are done in Python (3.12.2) with scipy (1.12.0), pythonmeta (1.26), numpy (1.26.4), statsmodels (0.14.1), and plotly (5.19.0).

Forest plots are computed using PythonMeta *Deng* with the DerSimonian and Laird random effects model (the fixed effect assumption is not plausible in this case) and inverse variance weighting. Results are presented with 95% confidence intervals. Heterogeneity among studies was assessed using the I^2 statistic. Mixed-effects meta-regression results are computed with R (4.1.2) using the metafor (3.0-2) and rms (6.2-0) packages, and using the most serious sufficiently powered outcome. For all statistical tests, a p-value less than 0.05 was considered statistically significant. Grobid 0.8.0 is used to parse PDF documents.

We have classified studies as early treatment if most patients are not already at a severe stage at the time of treatment (for example based on oxygen status or lung involvement), and treatment started within 5 days of the onset of symptoms. If studies contain a mix of early treatment and late treatment patients, we consider the treatment time of patients contributing most to the events (for example, consider a study where most patients are treated early but late treatment patients are included, and all mortality events were observed with late treatment patients). We note that a shorter time may be preferable. Antivirals are typically only considered effective when used within a shorter timeframe, for example 0-36 or 0-48 hours for oseltamivir, with longer delays not being effective *McLean, Treanor*.

We received no funding, this research is done in our spare time. We have no affiliations with any pharmaceutical companies or political parties.

A summary of study results is below. Please submit updates and corrections at https://c19early.org/exmeta.html.

Late treatment

Effect extraction follows pre-specified rules as detailed above and gives priority to more serious outcomes. For pooled analyses, the first (most serious) outcome is used, which may differ from the effect a paper focuses on. Other outcomes are used in outcome specific analyses.

Fernandez, 2/2/2023, retrospective, Chile, peer-reviewed, 10 authors.	risk of death, 47.5% lower, RR 0.53, $p = 0.02$, high activity levels 16 of 201 (8.0%), low activity levels 62 of 238 (26.1%), NNT 5.5, adjusted per study, odds ratio converted to relative risk, multivariable.

Prophylaxis

Effect extraction follows pre-specified rules as detailed above and gives priority to more serious outcomes. For pooled analyses, the first (most serious) outcome is used, which may differ from the effect a paper focuses on. Other outcomes are used in outcome specific analyses.

af Geijerstam, 7/5/2021, prospective, Sweden, peer-reviewed, 9 authors, study period March 2020 - September 2020.	risk of death, 50.0% lower, OR 0.50, $p = 0.005$, high vs. low fitness, model 7, RR approximated with OR.
	risk of ICU admission, 40.0% lower, OR 0.60, $p < 0.001$, high vs. low fitness, model 7, RR approximated with OR.
	risk of hospitalization, 27.0% lower, OR 0.73, $p < 0.001$, high vs. low fitness, model 7, RR approximated with OR.
Ahmadi, 8/31/2021, retrospective, United Kingdom, peer-reviewed, 5 authors.	risk of death, 30.0% lower, RR 0.70, $p = 0.005$, adjusted per study, sufficient vs. inactive, model 2, multivariable.
Akbar, 11/7/2023, retrospective, Qatar, preprint, mean age 40.3, 9 authors.	risk of case, 7.0% lower, OR 0.93, $p = 0.40$, high activity levels 3,333, low activity levels 3,333, adjusted per study, T3 vs. T1, multivariable, model 2, RR approximated with OR.
Almansour, 2/17/2022, retrospective, Saudi Arabia, peer-reviewed, 12 authors, study period April 2020 - June 2020.	risk of case, 5.7% lower, RR 0.94, $p = 0.85$, high activity levels 35 of 71 (49.3%), low activity levels 38 of 71 (53.5%), NNT 24, adjusted per study, odds ratio converted to relative risk, multivariable.
Antunes, 6/11/2022, retrospective, Brazil, peer-reviewed, survey, 5 authors, study period September 2020 - December 2020.	risk of ICU admission, 80.2% lower, RR 0.20, $p = 0.06$, high activity levels 1 of 14 (7.1%), low activity levels 9 of 25 (36.0%), NNT 3.5.
	risk of miscellaneous, 40.5% lower, RR 0.60, $p = 0.48$, high activity levels 3 of 14 (21.4%), low activity levels 9 of 25 (36.0%), NNT 6.9, CT abnormalities >50%.
	risk of miscellaneous, 72.5% lower, RR 0.27, $p = 0.04$, high activity levels 2 of 14 (14.3%), low activity levels 13 of 25 (52.0%), NNT 2.7, CT abnormalities 25-50%.
	hospitalization time, 43.4% lower, relative time 0.57, $p = 0.03$, high activity levels 14, low activity levels 25.
	miscellaneous, 25.5% lower, relative time 0.74, $p = 0.02$, high

	activity levels 14, low activity levels 25.
Baynouna AlKetbi, 8/23/2021, retrospective, United Arab Emirates, peer-reviewed, 16 authors.	risk of death, 98.5% lower, OR 0.01, $p = 0.049$, adjusted per study, multivariable, RR approximated with OR.
Beydoun, 3/12/2022, retrospective, USA, peer-reviewed, survey, 7 authors.	risk of case, 43.0% lower, OR 0.57, $p = 0.05$, high activity levels 1,710, low activity levels 448, adjusted per study, multivariable, >1/week vs. none, model 2, RR approximated with OR.
	risk of case, 62.0% lower, OR 0.38, $p = 0.010$, high activity levels 672, low activity levels 448, adjusted per study, multivariable, 1-4/mon vs. none, model 2, RR approximated with OR.
Bielik, 7/4/2021, retrospective, Slovakia, peer-reviewed, survey, 3 authors, study period 7 December, 2020 - 12 December, 2020.	risk of moderate case, 30.4% lower, RR 0.70, $p = 0.10$, high activity levels 775, low activity levels 365, adjusted per study, physically active group.
	risk of case, 9.1% higher, RR 1.09, $p = 0.36$, high activity levels 775, low activity levels 365, adjusted per study, physically active group.
Brandenburg, 7/1/2021, retrospective, multiple countries, peer-reviewed, survey, 4 authors.	risk of hospitalization, 6.0% higher, OR 1.06, $p = 0.60$, high activity levels 102, low activity levels 39, adjusted per study, multivariable, PA, >1h vigorous vs. no/low, RR approximated with OR.
	risk of hospitalization, 78.0% lower, OR 0.22, $p = 0.05$, high activity levels 177, low activity levels 34, adjusted per study, multivariable, CRF, 6.2-8.7 vs. >10, RR approximated with OR.
	risk of hospitalization, 64.0% lower, OR 0.36, $p = 0.04$, high activity levels 97, low activity levels 34, adjusted per study, multivariable, CRF, 8.7-10 vs. >10, RR approximated with OR.
	risk of severe case, 35.0% lower, OR 0.65, $p = 0.30$, high activity levels 102, low activity levels 39, adjusted per study, multivariable, PA, >1h vigorous vs. no/low, RR approximated with OR.
	risk of severe case, 24.0% lower, OR 0.76, $p = 0.60$, high activity levels 52, low activity levels 34, adjusted per study, multivariable, CRF, 4.4-6.2 vs. >10, RR approximated with OR.
Brawner, 10/10/2020, retrospective, USA, peer-reviewed, 10 authors, study period 29 February, 2020 - 30 May, 2020, excluded in exclusion analyses: unadjusted results with no group details.	risk of hospitalization, 74.2% lower, OR 0.26, $p = 0.001$, unadjusted, inverted to make OR<1 favor high activity levels, highest fitness quartile vs. lowest fitness quartile, RR approximated with OR.
Cardoso, 5/9/2023, retrospective, Brazil, peer-reviewed, 6 authors, study period April 2020 - February 2022.	risk of severe case, 73.0% lower, OR 0.27, $p < 0.001$, high activity levels 307, low activity levels 307, adjusted per study, inverted to make OR<1 favor high activity levels, case control OR, moderate/high vs. low physical activity, multivariable.
Cho, 4/6/2021, retrospective, South Korea, peer-reviewed, 9 authors.	risk of death, 53.0% lower, OR 0.47, $p = 0.01$, high activity levels 17 of 48 (35.4%) cases, 3,223 of 4,536 (71.1%) controls, case control OR, moderate to vigorous vs. inactive.

	risk of case, 10.0% lower, OR 0.90, $p < 0.001$, high activity levels 3,223 of 4,536 (71.1%) cases, 68,609 of 92,587 (74.1%) controls, NNT 142, case control OR, moderate to vigorous vs. inactive.
Christensen, 5/5/2021, prospective, United Kingdom, peer-reviewed, 5 authors, study period 16 March, 2020 - 26 July, 2020.	risk of death, 63.0% lower, RR 0.37, $p = 0.02$, high activity levels 543, low activity levels 529, adjusted per study, high fitness vs. low fitness, multivariable.
	risk of case, 23.0% lower, RR 0.77, $p = 0.20$, high activity levels 55 of 543 (10.1%), low activity levels 77 of 529 (14.6%), NNT 23, adjusted per study, high fitness vs. low fitness, multivariable.
de Souza, 9/30/2021, retrospective, Brazil, peer-reviewed, 8 authors, study period June 2020 - August 2020, trial NCT04396353 (history).	risk of mechanical ventilation, 73.2% lower, RR 0.27, $p = 0.07$, high activity levels 3 of 611 (0.5%), low activity levels 6 of 327 (1.8%), NNT 74, unadjusted, excluded in exclusion analyses: unadjusted results with no group details.
	risk of hospitalization, 34.3% lower, RR 0.66, $p = 0.046$, high activity levels 49 of 611 (8.0%), low activity levels 42 of 327 (12.8%), NNT 21, adjusted per study, sufficient vs. insufficient, model 3, multivariable.
Ekblom-Bak, 10/19/2021, retrospective, Sweden, peer-reviewed, 13 authors.	risk of severe case, 47.6% lower, OR 0.52, $p = 0.02$, inverted to make OR<1 favor high activity levels, case control OR, model 3, high vs. very low CRF.
Feter, 6/13/2023, retrospective, Brazil, peer-reviewed, survey, mean age 37.1, 17 authors.	risk of PASC, 26.0% lower, RR 0.74, $p = 0.02$, high activity levels 52, low activity levels 95, adjusted per study, before and during pandemic, multivariable.
	risk of PASC, 17.0% lower, RR 0.83, $p = 0.04$, high activity levels 67, low activity levels 170, adjusted per study, during pandemic, multivariable.
Frish, 6/15/2023, retrospective, Israel, peer-reviewed, 7 authors, study period 1 February, 2020 - 31 December, 2020.	risk of case, 53.0% lower, OR 0.47, $p = 0.04$, high activity levels 212, low activity levels 1,202, adjusted per study, >3 times per week vs. none, multivariable, RR approximated with OR.
Gao, 11/5/2020, retrospective, China, peer-reviewed, survey, median age 55.0, 11 authors, study period 10 February, 2020 - 1 March, 2020.	risk of case, 105.0% higher, HR 2.05, $p < 0.001$, high activity levels 59 of 105 (56.2%) cases, 69 of 210 (32.9%) controls, case control OR, Cox proportional hazards.
Gilley, 2/10/2022, retrospective, USA, peer-reviewed, survey, 21 authors, study period September 2020 - December 2020, trial NCT04766788 (history).	risk of case, 41.8% higher, RR 1.42, $p = 0.55$, high activity levels 172 of 1,917 (9.0%), low activity levels 5 of 79 (6.3%), unadjusted.
Green, 11/7/2022, retrospective, Israel, peer-reviewed, 9 authors, study period 1 February, 2020 - 31 December, 2020.	risk of case, 41.7% lower, RR 0.58, $p < 0.001$, high activity levels 1,267 of 11,144 (11.4%), low activity levels 16,198 of 101,931 (15.9%), adjusted per study, odds ratio converted to relative risk, >3 times per week vs. none, multivariable.
Halabchi (B), 12/1/2020, retrospective, Iran, peer-reviewed, 8 authors.	risk of death, 88.8% lower, RR 0.11, $p = 0.08$, high activity levels 0 of 249 (0.0%), low activity levels 79 of 4,445 (1.8%), NNT 56, adjusted per study, odds ratio converted to relative risk,

	multivariable.
	risk of hospitalization, 28.3% lower, RR 0.72, $p = 0.04$, high activity levels 30 of 249 (12.0%), low activity levels 878 of 4,445 (19.8%), adjusted per study, odds ratio converted to relative risk, multivariable.
Hamdan, 12/23/2021, retrospective, Palestine, peer-reviewed, survey, mean age 30.5, 7 authors.	**risk of hospitalization, 16.4% lower, RR 0.84, $p = 0.53$**, high activity levels 22 of 128 (17.2%), low activity levels 37 of 172 (21.5%), NNT 23, adjusted per study, odds ratio converted to relative risk, multivariable.
Hamer, 7/31/2020, retrospective, United Kingdom, peer-reviewed, 4 authors.	**risk of hospitalization, 27.5% lower, RR 0.72, $p < 0.001$**, adjusted per study, inverted to make RR<1 favor high activity levels, model 2, sufficient vs. no activity, multivariable.
	risk of hospitalization, 33.8% lower, RR 0.66, $p < 0.001$, adjusted per study, inverted to make RR<1 favor high activity levels, model 1, sufficient vs. no activity, multivariable.
Hamrouni, 11/3/2021, prospective, United Kingdom, peer-reviewed, 5 authors.	**risk of death, 29.0% lower, RR 0.71, $p = 0.009$**, high activity levels 138 of 106,006 (0.1%), low activity levels 109 of 47,827 (0.2%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, high vs. low physical activity, multivariable.
Hegazy, 10/2/2023, retrospective, Egypt, peer-reviewed, 7 authors, study period May 2021 - February 2022, trial NCT04447144 (history), excluded in exclusion analyses: unadjusted results with no group details.	**risk of moderate case, 54.0% lower, RR 0.46, $p = 0.010$**, high activity levels 15 of 50 (30.0%), low activity levels 15 of 23 (65.2%), NNT 2.8, active vs. inactive.
	risk of moderate case, 97.1% lower, RR 0.03, $p = 0.02$, high activity levels 0 of 7 (0.0%), low activity levels 30 of 61 (49.2%), NNT 2.0, relative risk is not 0 because of continuity correction due to zero events (with reciprocal of the contrasting arm), moderate vs. low/inactive.
Ho, 11/19/2020, retrospective, United Kingdom, peer-reviewed, survey, 13 authors.	**risk of hospitalization, 34.6% lower, RR 0.65, $p = 0.007$**, high activity levels 213 of 123,588 (0.2%), low activity levels 59 of 14,887 (0.4%), adjusted per study, inverted to make RR<1 favor high activity levels, model 2, average vs. slow walking pace, multivariable.
Holt, 3/30/2021, prospective, United Kingdom, peer-reviewed, 34 authors, study period 1 May, 2020 - 5 February, 2021, trial NCT04330599 (history) (COVIDENCE UK).	**risk of case, 17.0% lower, OR 0.83, $p = 0.18$**, adjusted per study, fully adjusted, ≥2 hours lower impact physical activity vs. 0 hours, RR approximated with OR.
Huang, 11/30/2021, retrospective, China, peer-reviewed, survey, 5 authors, study period 10 February, 2020 - 28 March, 2020.	**risk of severe case, 46.8% lower, RR 0.53, $p = 0.18$**, high activity levels 7 of 74 (9.5%), low activity levels 16 of 90 (17.8%), NNT 12, unadjusted, exercise habit, ≥1 time per week, excluded in exclusion analyses: unadjusted results with no group details.
	risk of severe case, 8.0% lower, RR 0.92, $p = 1.00$, high activity levels 3 of 23 (13.0%), low activity levels 20 of 141 (14.2%), NNT 88, unadjusted, ≥30 minutes ≥3 times per week, excluded in exclusion analyses: unadjusted results with no group details.

	risk of case, 65.9% lower, OR 0.34, $p = 0.004$, adjusted per study, inverted to make OR<1 favor high activity levels, case control OR, regular exercise, multivariable.
Kapusta, 12/12/2022, retrospective, Poland, peer-reviewed, survey, mean age 70.4, 7 authors, study period 1 March, 2020 - 30 August, 2020, trial NCT05018052 (history).	**risk of severe case, 70.9% lower, OR 0.29, $p = 0.001$**, high activity levels 181, low activity levels 387, inverted to make OR<1 favor high activity levels, RR approximated with OR.
Kontopoulou, 4/17/2022, retrospective, Greece, peer-reviewed, survey, 4 authors, study period November 2020 - December 2020, excluded in exclusion analyses: unadjusted results with no group details.	**recovery time, 66.2% lower, relative time 0.34, $p < 0.001$**, high activity levels mean 22.0 (±14.0) n=42, low activity levels mean 65.0 (±32.0) n=24.
	relative dyspnea after hospitalization, 66.7% better, RR 0.33, $p < 0.001$, high activity levels mean 1.0 (±1.0) n=42, low activity levels mean 3.0 (±1.0) n=24, inverted to make RR<1 favor high activity levels.
Latorre-Román, 6/15/2021, retrospective, Spain, peer-reviewed, survey, 7 authors.	**risk of hospitalization, 76.0% lower, OR 0.24, $p = 0.05$**, moderate physical activity, >150 min per week, RR approximated with OR.
	risk of hospitalization, 87.0% lower, OR 0.13, $p = 0.07$, moderate physical activity, 30-150 min per week, RR approximated with OR.
Lee, 7/22/2021, retrospective, South Korea, peer-reviewed, 25 authors, study period 1 January, 2020 - 31 July, 2020.	**risk of death, 74.0% lower, RR 0.26, $p = 0.046$**, high activity levels 2 of 11,072 (0.0%), low activity levels 32 of 41,293 (0.1%), NNT 1683, adjusted per study, odds ratio converted to relative risk, model 2,aerobic and muscle strengthening vs. insufficient aerobic and muscle strengthening, multivariable.
	risk of severe case, 57.8% lower, RR 0.42, $p = 0.03$, high activity levels 39 of 11,072 (0.4%), low activity levels 273 of 41,293 (0.7%), adjusted per study, odds ratio converted to relative risk, model 2,aerobic and muscle strengthening vs. insufficient aerobic and muscle strengthening, multivariable.
	risk of case, 15.6% lower, RR 0.84, $p = 0.03$, high activity levels 291 of 11,072 (2.6%), low activity levels 1,293 of 41,293 (3.1%), NNT 199, adjusted per study, odds ratio converted to relative risk, model 2,aerobic and muscle strengthening vs. insufficient aerobic and muscle strengthening, multivariable.
Lengelé, 10/23/2021, prospective, Belgium, peer-reviewed, median age 75.6, 8 authors, study period March 2020 - April 2021.	**risk of case, 73.6% lower, RR 0.26, $p = 0.03$**, high activity levels 23 of 229 (10.0%), low activity levels 4 of 12 (33.3%), NNT 4.3, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk.
Li (B), 2/3/2021, retrospective, United Kingdom, peer-reviewed, 2 authors, per SD increase.	**risk of severe case, 81.0% lower, OR 0.19, $p = 0.02$**, RR approximated with OR.
	risk of hospitalization, 56.0% lower, OR 0.44, $p = 0.07$, RR approximated with OR.

Lin, 9/21/2021, prospective, multiple countries, peer-reviewed, survey, 19 authors, study period 26 March, 2020 - 8 October, 2020.	risk of case, 47.4% lower, OR 0.53, $p = 0.40$, inverted to make OR<1 favor high activity levels, exercise ≥1/month vs. exercise <1/month, RR approximated with OR.
Lobelo, 5/19/2021, retrospective, Georgia, peer-reviewed, 7 authors, study period 3 March, 2020 - 29 October, 2020.	risk of hospitalization, 20.0% lower, OR 0.80, $p = 0.02$, high activity levels 2,121, low activity levels 1,648, adjusted per study, inverted to make OR<1 favor high activity levels, active vs. inactive, multivariable, RR approximated with OR.
Malisoux, 4/29/2022, retrospective, Luxembourg, peer-reviewed, survey, median age 42.0, 6 authors, study period May 2020 - June 2021, trial NCT04380987 (history).	risk of progression, 63.0% lower, OR 0.37, $p = 0.045$, high activity levels 115, low activity levels 108, moderate case, >82 vs. <30 MET-hour/week, RR approximated with OR.
	risk of progression, 52.0% lower, OR 0.48, $p = 0.14$, high activity levels 116, low activity levels 108, moderate case, >52-82 vs. <30 MET-hour/week, RR approximated with OR.
	risk of progression, 43.0% lower, OR 0.57, $p = 0.28$, high activity levels 113, low activity levels 108, moderate case, 30-52 vs. <30 MET-hour/week, RR approximated with OR.
Maltagliati, 8/11/2021, retrospective, multiple countries, peer-reviewed, survey, 8 authors.	risk of hospitalization, 52.0% lower, OR 0.48, $p = 0.02$, adjusted per study, model 1, more than once a week vs. hardly ever or never, multivariable, RR approximated with OR.
Marcus, 6/17/2021, prospective, multiple countries, peer-reviewed, survey, 12 authors, study period 26 March, 2020 - 3 May, 2020.	risk of symptomatic case, 42.1% lower, RR 0.58, $p < 0.001$, high activity levels 240 of 10,627 (2.3%), low activity levels 134 of 3,708 (3.6%), NNT 74, adjusted per study, odds ratio converted to relative risk, multivariable.
Mohsin, 9/30/2021, retrospective, Bangladesh, peer-reviewed, survey, 10 authors, study period November 2020 - April 2021, excluded in exclusion analyses: unadjusted results with no group details.	risk of severe case, 19.0% lower, RR 0.81, $p = 0.04$, high activity levels 86 of 258 (33.3%), low activity levels 224 of 544 (41.2%), NNT 13, exercise >30 minutes.
	risk of severe case, 0.9% higher, RR 1.01, $p = 0.91$, high activity levels 290 of 698 (41.5%), low activity levels 224 of 544 (41.2%), exercise <30 minutes.
Muñoz-Vergara, 2/13/2024, prospective, USA, peer-reviewed, 7 authors.	risk of hospitalization, 26.7% lower, RR 0.73, $p = 0.002$, high activity levels 332 of 42,159 (0.8%), low activity levels 203 of 12,405 (1.6%), adjusted per study, odds ratio converted to relative risk, sufficiently active vs. inactive, multivariable, model 3.
	risk of case, 9.1% lower, RR 0.91, $p = 0.004$, high activity levels 3,898 of 42,159 (9.2%), low activity levels 1,293 of 12,405 (10.4%), NNT 85, adjusted per study, odds ratio converted to relative risk, sufficiently active vs. inactive, multivariable, model 3.
Nguyen, 9/18/2021, retrospective, Vietnam, peer-reviewed, survey, 17 authors, study period 14 February, 2020 - 2 March, 2020.	risk of symptomatic case, 20.3% lower, RR 0.80, $p < 0.001$, high activity levels 904 of 2,836 (31.9%), low activity levels 483 of 1,111 (43.5%), NNT 8.6, adjusted per study, odds ratio converted to relative risk, active vs. inactive, COVID-19-like symptoms, multivariable.

Park, 2/14/2023, retrospective, South Korea, peer-reviewed, survey, 4 authors, study period 1 January, 2020 - 14 August, 2020.	risk of death, 25.6% lower, OR 0.74, $p = 0.08$, inverted to make OR<1 favor high activity levels, sufficient vs. insufficient PA, model 3, RR approximated with OR.
	risk of death, 38.4% lower, OR 0.62, $p = 0.02$, inverted to make OR<1 favor high activity levels, sufficient vs. insufficient PA, model 2, RR approximated with OR.
	risk of case, 7.2% lower, OR 0.93, $p = 0.02$, inverted to make OR<1 favor high activity levels, sufficient vs. insufficient PA, model 3, RR approximated with OR.
	risk of case, 10.4% lower, OR 0.90, $p < 0.001$, inverted to make OR<1 favor high activity levels, sufficient vs. insufficient PA, model 2, RR approximated with OR.
Paul, 4/13/2022, retrospective, United Kingdom, preprint, survey, 2 authors.	risk of long COVID, 38.1% lower, RR 0.62, $p = 0.16$, adjusted per study, odds ratio converted to relative risk, 3+ hours per week vs. none, multivariable, model 4, control prevalance approximated with overall prevalence.
	risk of long COVID, 4.1% lower, RR 0.96, $p = 0.89$, adjusted per study, odds ratio converted to relative risk, ≤2 hours per week vs. none, multivariable, model 4, control prevalance approximated with overall prevalence.
Pavlidou, 11/9/2023, retrospective, Greece, peer-reviewed, 14 authors.	risk of case, 42.2% lower, OR 0.58, $p = 0.001$, high activity levels 902, low activity levels 4,295, adjusted per study, inverted to make OR<1 favor high activity levels, high vs. low/moderate IPAQ, multivariable, RR approximated with OR.
Pitanga, 10/29/2022, retrospective, Brazil, peer-reviewed, survey, 11 authors.	risk of case, 33.0% lower, OR 0.67, $p = 0.05$, high activity levels 1,469, low activity levels 1,552, combined results with and without protection practices, RR approximated with OR.
Pływaczewska-Jakubowska, 10/24/2022, retrospective, Poland, peer-reviewed, median age 51.0, 5 authors, study period May 2020 - January 2022.	risk of moderate/severe case, 11.0% lower, OR 0.89, $p = 0.30$, high activity levels 490, low activity levels 1,357, adjusted per study, multivariable, model 3, RR approximated with OR.
	risk of PASC, 14.0% lower, OR 0.86, $p = 0.24$, high activity levels 389, low activity levels 1,128, adjusted per study, multivariable, model 3, RR approximated with OR.
Reis, 10/24/2022, retrospective, USA, peer-reviewed, survey, 6 authors, study period December 2020 - February 2021.	risk of hospitalization, 40.7% lower, RR 0.59, $p = 0.18$, high activity levels 9 of 241 (3.7%), low activity levels 29 of 305 (9.5%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, strength training 2+/week vs. <2, multivariable.
Saadeh, 10/30/2021, retrospective, Sweden, peer-reviewed, 6 authors, study period March 2020 - June 2020.	risk of symptomatic case, 9.1% lower, OR 0.91, $p = 0.71$, high activity levels 362, low activity levels 225, adjusted per study, inverted to make OR<1 favor high activity levels, 2+ symptoms, Table 8, physically active vs. inactive, multivariable, RR approximated with OR.

	risk of symptomatic case, 3.8% lower, OR 0.96, $p = 0.85$, high activity levels 362, low activity levels 225, adjusted per study, inverted to make OR<1 favor high activity levels, 1+ symptoms, Table 2, model 2, physically active vs. inactive, multivariable, RR approximated with OR.
Salgado-Aranda, 3/14/2022, retrospective, Spain, peer-reviewed, 15 authors, study period 15 February, 2020 - 15 April, 2020.	**risk of death, 83.1% lower, HR 0.17, $p = 0.003$**, high activity levels 4 of 223 (1.8%), low activity levels 41 of 297 (13.8%), NNT 8.3, inverted to make HR<1 favor high activity levels, active vs. sedentary, Cox proportional hazards.
Sallis, 4/13/2021, retrospective, USA, peer-reviewed, 8 authors.	**risk of death, 59.2% lower, RR 0.41, $p = 0.005$**, high activity levels 11 of 3,118 (0.4%), low activity levels 170 of 6,984 (2.4%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, consistently active vs. consistently inactive, multivariable.
	risk of ICU admission, 41.5% lower, RR 0.58, $p = 0.006$, high activity levels 32 of 3,118 (1.0%), low activity levels 195 of 6,984 (2.8%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, consistently active vs. consistently inactive, multivariable.
	risk of hospitalization, 53.0% lower, RR 0.47, $p < 0.001$, high activity levels 99 of 3,118 (3.2%), low activity levels 732 of 6,984 (10.5%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, consistently active vs. consistently inactive, multivariable.
Sanchez, 4/25/2023, retrospective, Spain, peer-reviewed, 3 authors, trial NCT04624048 (history).	**risk of symptomatic case, 54.1% lower, OR 0.46, $p < 0.001$**, inverted to make OR<1 favor high activity levels, exercise vs. no exercise before COVID-19, RR approximated with OR.
Schmidt, 6/21/2023, retrospective, Germany, peer-reviewed, 8 authors, CoCo-Fakt trial.	**risk of case, 31.1% lower, OR 0.69, $p = 0.02$**, high activity levels 956, low activity levels 2,705, adjusted per study, inverted to make OR<1 favor high activity levels, above guidelines vs. below guidelines, multivariable, RR approximated with OR.
	risk of case, 34.5% lower, OR 0.66, $p = 0.02$, high activity levels 956, low activity levels 1,113, adjusted per study, inverted to make OR<1 favor high activity levels, above guidelines vs. meeting guidelines, multivariable, RR approximated with OR.
	risk of case, 22.7% lower, OR 0.77, $p = 0.02$, high activity levels 3,658, low activity levels 1,680, adjusted per study, inverted to make OR<1 favor high activity levels, exercise vs. no exercise, multivariable, RR approximated with OR.
	risk of case, 21.6% lower, OR 0.78, $p = 0.03$, high activity levels 3,371, low activity levels 1,716, adjusted per study, inverted to make OR<1 favor high activity levels, moderate-to-vigorous vs. low intensity, multivariable, RR approximated with OR.
Steenkamp, 2/9/2022, retrospective, South Africa, peer-reviewed, 10 authors, study period 19 March, 2020 - 30 June, 2021.	**risk of death, 42.0% lower, RR 0.58, $p < 0.001$**, high activity levels 29,469, low activity levels 13,366, adjusted per study, high activity vs. low activity, poisson regression, multivariable.

	risk of mechanical ventilation, 45.0% lower, RR 0.55, $p < 0.001$, high activity levels 29,469, low activity levels 13,366, adjusted per study, high activity vs. low activity, poisson regression, multivariable.
	risk of ICU admission, 41.0% lower, RR 0.59, $p < 0.001$, high activity levels 29,469, low activity levels 13,366, adjusted per study, high activity vs. low activity, poisson regression, multivariable.
	risk of hospitalization, 34.0% lower, RR 0.66, $p < 0.001$, high activity levels 29,469, low activity levels 13,366, adjusted per study, high activity vs. low activity, poisson regression, multivariable.
Sutkowska, 6/14/2023, prospective, Poland, peer-reviewed, 14 authors, study period 31 January, 2022 - 11 February, 2022, trial NCT05200767 (history).	risk of death, 62.0% lower, HR 0.38, $p = 0.21$, high activity levels 71, low activity levels 60, inverted to make HR<1 favor high activity levels, IPAQ 1/2 vs. IPAQ 0, Cox proportional hazards.
	risk of no recovery, 61.0% lower, HR 0.39, $p = 0.19$, high activity levels 71, low activity levels 60, IPAQ 1/2 vs. IPAQ 0, Cox proportional hazards.
Tavakol, 2/4/2021, retrospective, Iran, peer-reviewed, 9 authors, study period 20 March, 2020 - 24 April, 2020.	risk of severe case, 68.5% lower, RR 0.31, $p = 0.05$, high activity levels 3 of 64 (4.7%), low activity levels 19 of 124 (15.3%), NNT 9.4, adjusted per study, odds ratio converted to relative risk, moderate to high activity versus low activity, multivariable.
Tret'yakov, 10/26/2020, retrospective, Russia, peer-reviewed, 8 authors, excluded in exclusion analyses: unadjusted results with no group details.	risk of severe case, 98.3% lower, RR 0.02, $p = 0.007$, high activity levels 0 of 27 (0.0%), low activity levels 53 of 266 (19.9%), NNT 5.0, relative risk is not 0 because of continuity correction due to zero events (with reciprocal of the contrasting arm).
Tsuzuki, 7/5/2022, retrospective, Japan, preprint, 4 authors, study period 1 January, 2022 - 16 May, 2022.	risk of severe case, 56.3% lower, OR 0.44, $p < 0.001$, high activity levels 3,340, low activity levels 1,528, adjusted per study, inverted to make OR<1 favor high activity levels, good vs. poor physical activity status, multivariable, RR approximated with OR.
Wang, 1/31/2024, prospective, United Kingdom, preprint, 10 authors.	risk of death, 30.0% lower, HR 0.70, $p < 0.001$, high activity levels 57,930, low activity levels 10,966, adjusted per study, ≥150 min/wk moderate or ≥75 min/wk vigorous vs. < 75 min/wk vigorous, multivariable.
	risk of hospitalization, 12.0% lower, HR 0.88, $p < 0.001$, high activity levels 57,930, low activity levels 10,966, adjusted per study, ≥150 min/wk moderate or ≥75 min/wk vigorous vs. < 75 min/wk vigorous, multivariable.
	risk of PASC, 14.0% lower, HR 0.86, $p < 0.001$, high activity levels 57,930, low activity levels 10,966, adjusted per study, ≥150 min/wk moderate or ≥75 min/wk vigorous vs. < 75 min/wk vigorous, multivariable.

Wang (B), 2/6/2023, prospective, USA, peer-reviewed, survey, mean age 64.7, 8 authors, study period April 2020 - November 2021.	**risk of PASC, 10.7% lower, RR 0.89, $p = 0.20$**, high activity levels 274 of 691 (39.7%), low activity levels 283 of 594 (47.6%), NNT 13, adjusted per study, inverted to make RR<1 favor high activity levels, ≥210 vs. 0-30, multivariable, model 2.
	risk of PASC, 49.0% lower, RR 0.51, $p = 0.002$, high activity levels 188, low activity levels 66, 5 or 6 healthy lifestyle factors vs. 0.
Yates, 2/26/2021, retrospective, United Kingdom, peer-reviewed, 7 authors.	**risk of death, 45.3% lower, RR 0.55, $p = 0.001$**, high activity levels 72 of 163,912 (0.0%), low activity levels 62 of 30,119 (0.2%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, multivariable.
	risk of severe case, 46.7% lower, RR 0.53, $p < 0.001$, high activity levels 291 of 163,912 (0.2%), low activity levels 180 of 30,119 (0.6%), adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, multivariable.
Young, 12/14/2022, retrospective, USA, peer-reviewed, 7 authors, study period 1 January, 2020 - 31 May, 2021.	**risk of death, 74.4% lower, OR 0.26, $p < 0.001$**, high activity levels 11,279, low activity levels 29,099, inverted to make OR<1 favor high activity levels, always active vs. always inactive, RR approximated with OR.
	risk of death, 65.3% lower, OR 0.35, $p < 0.001$, high activity levels 11,279, low activity levels 83,452, inverted to make OR<1 favor high activity levels, always active vs. mostly inactive, RR approximated with OR.
	risk of death, 47.9% lower, OR 0.52, $p < 0.001$, high activity levels 11,279, low activity levels 42,490, inverted to make OR<1 favor high activity levels, always active vs. some activity, RR approximated with OR.
	risk of death, 35.5% lower, OR 0.65, $p = 0.002$, high activity levels 11,279, low activity levels 27,871, inverted to make OR<1 favor high activity levels, always active vs. consistently active, RR approximated with OR.
	risk of hospitalization, 47.6% lower, OR 0.52, $p < 0.001$, high activity levels 11,279, low activity levels 29,099, inverted to make OR<1 favor high activity levels, always active vs. always inactive, RR approximated with OR.
	risk of hospitalization, 41.9% lower, OR 0.58, $p < 0.001$, high activity levels 11,279, low activity levels 83,452, inverted to make OR<1 favor high activity levels, always active vs. mostly inactive, RR approximated with OR.
	risk of hospitalization, 30.1% lower, OR 0.70, $p < 0.001$, high activity levels 11,279, low activity levels 42,490, inverted to make OR<1 favor high activity levels, always active vs. some activity, RR approximated with OR.

	risk of hospitalization, 20.0% lower, OR 0.80, $p < 0.001$, high activity levels 11,279, low activity levels 27,871, inverted to make OR<1 favor high activity levels, always active vs. consistently active, RR approximated with OR.
Yuan, 6/20/2021, retrospective, China, peer-reviewed, 9 authors, study period 15 February, 2020 - 14 March, 2020.	**risk of death, 90.5% lower, RR 0.09, $p = 0.09$**, high activity levels 0 of 61 (0.0%), low activity levels 6 of 103 (5.8%), NNT 17, relative risk is not 0 because of continuity correction due to zero events (with reciprocal of the contrasting arm), excluded in exclusion analyses: excessive unadjusted differences between groups.
	risk of severe case, 70.0% lower, RR 0.30, $p = 0.03$, high activity levels 3 of 61 (4.9%), low activity levels 26 of 103 (25.2%), NNT 4.9, adjusted per study, inverted to make RR<1 favor high activity levels, odds ratio converted to relative risk, multivariable.
Zhang (B), 12/6/2020, retrospective, United Kingdom, peer-reviewed, 9 authors.	**risk of death, 26.0% lower, OR 0.74, $p = 0.17$**, adjusted per study, AMPA, per SD increase, multivariable, RR approximated with OR.
	risk of case, 18.0% lower, OR 0.82, $p = 0.01$, adjusted per study, AMPA, per SD increase, multivariable, RR approximated with OR.
Šebić, 7/15/2023, retrospective, Bosnia and Herzegovina, peer-reviewed, 5 authors.	**risk of oxygen therapy, 89.5% lower, RR 0.11, $p = 0.045$**, high activity levels 0 of 53 (0.0%), low activity levels 4 of 47 (8.5%), NNT 12, relative risk is not 0 because of continuity correction due to zero events (with reciprocal of the contrasting arm).
	risk of hospitalization, 91.4% lower, RR 0.09, $p = 0.02$, high activity levels 0 of 53 (0.0%), low activity levels 5 of 47 (10.6%), NNT 9.4, relative risk is not 0 because of continuity correction due to zero events (with reciprocal of the contrasting arm).
	risk of progression, 83.9% lower, RR 0.16, $p < 0.001$, high activity levels 4 of 53 (7.5%), low activity levels 22 of 47 (46.8%), NNT 2.5, pneumonia.
	no recovery, 47.3% lower, RR 0.53, $p < 0.001$, high activity levels 22 of 53 (41.5%), low activity levels 37 of 47 (78.7%), NNT 2.7, day 14.

Supplementary Data

Supplementary Data

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