Contents of supplementary appendix

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Table S1. Sensitivity analyses and justification.

Sensitivity analysis (1 to 8)	Cohort	Justification
1. Primary endpoint analysis	Cohort A	- Main results - The "primary endpoint" was positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death.
2. Subgroup analysis of the risk of positive SARS-CoV-2 test, severe COVID-19 outcomes, or COVID-19-related death in patients who engaged in physical activities stratified by age groups, gender, smoking status, and Charlson comorbidity index	Cohort A	- To test the stability of our main results, we performed subgroup analysis, in which there was stratification according to age groups, gender, smoking status, and Charlson comorbidity index.
3. Main analysis after propensity score matching	Matched cohorts A, C, and D	- We performed propensity score matching to reduce potential confounding effects and balance the baseline characteristics (matched cohort A, insufficient aerobic and muscle strengthening versus aerobic and muscle strengthening; matched cohort C and D, insufficient

		physical activity [MET, 0 to 500] versus sufficient physical activity [MET, ≥ 500]). And then we repeated the main analysis after propensity score matching.
4. After restricting to only patients with COVID-19	Cohorts B and E	- We repeated the main analysis, including only COVID-19 patients.
5. Redefined cohort using alternative "exposure" definition	Cohorts C, D, and E	- To test the stability and reliability of our results, we conducted two differential conditions of "exposure" such as using the physical activity guidelines (cohort A and B) and MET score (cohort C, D, and E).
6. Extended cohort	Cohorts D and E	- We extended and linked the national general health examination to 2015 instead of 2018. This extended cohort increased the generalizability and reliability of our main results.
7. Secondary endpoint analysis	Cohorts B and E	- The "secondary endpoint" was the length of hospital stay among COVID-19 confirmed patients.

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| 8. DAG approach | Cohorts A to E and matched cohorts A, C and E | - To avoid overfitting issues, we conducted minimal selected matching covariates in the original cohort. DAGs can be used to select covariates for support causal interpretation.

- Selected confounders by DAGs were selected for age, sex, region of residence, household income, smoking, and alcoholic drinks. |
| 9. Sidak's correction for multiple comparisons | Cohorts A and D | - We used the Sidak's correction for multiple comparisons to reduce the probability of type 1 error. |

Abbreviations: COVID-19, coronavirus disease; DAGs, directed acyclic graphs; MET, metabolic equivalent of task; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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Table S2. Propensity score-matched baseline covariates and adjusted relative risks (95% confidence intervals) of SARS-CoV-2 infection, severe COVID-19 outcomes, and COVID-19 related death associated with study patients who engaged in physical activities according to exercise guideline (patients with insufficient aerobic and muscle strengthening versus those with aerobic and muscle strengthening; propensity score matched A)

Characteristic	Types of physical activity		SMD
	Insufficient aerobic and muscle strengthening	Aerobic and muscle strengthening	
Total, n (%)	2649	2649	
Age, years, n (%)			0.003
20-39	622 (23.5)	656 (24.8)	
40-59	1286 (48.6)	1212 (45.8)	
≥ 60	741 (28.0)	781 (29.5)	
Sex, n (%)			0.006

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Male	1959 (74.0)	1967 (74.3)	
Female	690 (26.1)	682 (25.8)	
Region of residence, n (%)			0.015
Seoul Capital Area	1215 (45.9)	1207 (45.6)	
Daegu/Gyeongbuk area	495 (18.7)	476 (18.0)	
Other area	939 (35.5)	966 (36.5)	
Charlson comorbidity index, n (%)			0.030
0	1479 (55.8)	1463 (55.2)	
1	383 (14.5)	343 (13.0)	
≥2	787 (29.7)	843 (31.8)	
History of diabetes mellitus, n (%)	235 (8.9)	253 (9.6)	0.022

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History of tuberculosis, n (%)	57 (2.2)	62 (2.3)	0.013
History of stroke, n (%)	39 (1.5)	33 (1.3)	0.017
History of cardiovascular disease, n (%)	95 (3.6)	94 (3.6)	0.002
History of hypertension, n (%)	499 (18.8)	544 (20.5)	0.040
History of dyslipidemia, n (%)	196 (7.4)	198 (7.5)	0.003
Body mass index, kg/m^2, n (%)			0.011
<25	1615 (61.0)	1609 (60.7)	
25–30	857 (32.4)	886 (33.5)	
≥30	177 (6.7)	154 (5.8)	
Systolic blood pressure, mmHg, mean (SD)	122.4 (14.6)	123.0 (13.6)	0.040
Diastolic blood pressure, mmHg, mean (SD)	75.7 (10.1)	76.1 (9.6)	0.034

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Fasting blood glucose, mg/dL, mean (SD)	101.2 (24.9)	101.5 (25.0)	0.011
Serum total cholesterol, mg/dL, mean (SD)	192.6 (39.1)	191.5 (38.7)	0.028
Glomerular filtration rate, ml/min, n (%)			0.036
≥90	1313 (49.6)	1208 (45.6)	
60-89	1173 (44.3)	1326 (50.1)	
≤59	163 (6.2)	115 (4.3)	
Household income, n (%)			0.012
Low (0–39 percentile)	644 (24.3)	667 (25.2)	
Middle (40–79 percentile)	1102 (41.6)	1080 (40.8)	
High (80–100 percentile)	903 (34.1)	902 (34.1)	
Smoking, n (%)			0.023

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Never smoker	1366 (51.6)	1296 (48.9)	
Ex-smoker	586 (22.1)	774 (29.2)	
Current smoker	697 (26.3)	579 (21.9)	
Alcoholic drinks, days per week, n (%)			0.002
<1	1540 (58.1)	1465 (55.3)	
1–2	710 (26.8)	840 (31.7)	
3–4	293 (11.1)	82 (3.1)	
≥5	106 (4.0)	82 (3.1)	
Use of medication, n (%)			
Medication for hypertension, n (%)	466 (17.6)	507 (19.1)	0.037
Medication for dyslipidemia, n (%)	163 (6.2)	162 (6.1)	0.001

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Medication for diabetes mellitus, n (%)	218 (8.2)	235 (8.9)	0.021
Medication for cardiovascular disease, n (%)	84 (3.2)	86 (3.3)	0.004
COVID-19, n (%)	95 (3.6)	69 (2.6)	
Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.72 (0.53 to 0.99)**	
Model 2[§] (fully adjusted)	1.0 (ref)	**0.73 (0.54 to 0.99)**	
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	**0.73 (0.54 to 0.99)**	
Severe COVID-19[‡], n (%)	21 (0.79)	9 (0.34)	
Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.41 (0.18 to 0.94)**	
Model 2[§] (fully adjusted)	1.0 (ref)	**0.43 (0.20 to 0.95)**	
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	**0.41 (0.18 to 0.95)**	
COVID-19 related death, n (%)	3 (0.11)	1 (0.04)	

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Model 1* (age and sex adjusted)	1.0 (ref)	0.31 (0.02 to 3.17)
Model 2§ (fully adjusted)	1.0 (ref)	0.34 (0.04 to 3.20)
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	0.32 (0.02 to 3.18)

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; DAGs, directed acyclic graphs; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation; SMD, standardized mean difference.

* Model 1: adjusted for age (20−39, 40−59, and ≥60 years) and sex.

§ Model 2: adjusted for the age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other areas); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

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ǁ Model 3: adjusted for potential confounders selected by DAGs (age; sex; region of residence; household income; smoking; and alcoholic

drinks).

‡ Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

An SMD of less than 0.1 indicates no major imbalance. All SMD values were less than 0.04 in the propensity-score-matched cohort.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S3. Baseline covariates and adjusted relative risks (95% confidence intervals) of severe COVID-19 outcomes and COVID-19 related death associated with laboratory COVID-19 confirmed patients engaging in physical activities according to exercise guideline (total n = 2295; cohort B)

Characteristic	Types of physical activity			
	Insufficient aerobic and muscle strengthening	Muscle strengthening only	Aerobic only	Aerobic and muscle strengthening
Total, n (%)	1293 (56.3)	150 (6.5)	561 (24.4)	291 (12.7)
Age, years, n (%)				
20-39	203 (15.7)	44 (29.3)	92 (16.4)	74 (25.4)
40-59	627 (48.5)	68 (45.3)	261 (46.5)	139 (47.8)
≥ 60	463 (35.8)	38 (25.3)	208 (37.1)	78 (26.8)
Sex, n (%)				

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Male	420 (32.6)	84 (56.0)	231 (41.2)	164 (56.4)
Female	873 (67.5)	66 (44.0)	330 (58.8)	127 (43.6)
Region of residence, n (%)				
Seoul Capital Area	158 (12.2)	18 (12.0)	72 (12.8)	42 (14.4)
Daegu/Gyeongbuk area	1015 (78.9)	115 (76.7)	433 (77.2)	206 (70.8)
Other area	120 (9.3)	17 (11.3)	56 (10.0)	43 (14.8)
Charlson comorbidity index, n (%)				
0	769 (59.5)	104 (69.3)	334 (59.5)	185 (63.6)
1	193 (14.9)	16 (10.7)	88 (15.7)	35 (12.0)
$\geq$2	331 (25.6)	30 (20.0)	139 (24.8)	71 (24.4)
History of diabetes mellitus, n (%)	128 (9.9)	10 (6.7)	53 (9.5)	25 (8.6)

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History of tuberculosis, n (%)	27 (2.1)	3 (2.0)	10 (1.8)	3 (1.0)
History of stroke, n (%)	19 (1.5)	0 (0.0)	11 (2.0)	2 (0.7)
History of cardiovascular disease, n (%)	28 (2.2)	4 (2.7)	10 (1.8)	5 (1.7)
History of hypertension, n (%)	262 (20.3)	19 (12.7)	123 (21.9)	50 (17.2)
History of dyslipidemia, n (%)	86 (6.7)	12 (8.0)	43 (7.7)	11 (3.8)
Body mass index, kg/m^2, n (%)				
<25	792 (61.3)	98 (65.3)	349 (62.2)	178 (61.2)
25–30	432 (33.4)	44 (29.3)	188 (33.5)	98 (33.7)
≥30	69 (5.3)	8 (5.3)	24 (4.3)	15 (5.2)
Systolic blood pressure, mmHg, mean (SD)	121.0 (15.5)	120.4 (14.4)	121.5 (15.7)	120.5 (14.5)
Diastolic blood pressure, mmHg, mean (SD)	74.8 (10.5)	74.7 (9.3)	74.9 (10.0)	75.1 (9.6)

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Fasting blood glucose, mg/dL, mean (SD)	100.6 (25.3)	95.9 (18.0)	101.7 (26.2)	99.0 (18.7)
Serum total cholesterol, mg/dL, mean (SD)	196.2 (39.2)	191.7 (49.2)	191.9 (40.3)	190.6 (36.8)
Glomerular filtration rate, ml/min, n (%)				
≥90	621 (48.4)	81 (54.0)	272 (48.7)	130 (44.8)
60-89	590 (46.0)	61 (40.7)	259 (46.3)	155 (53.5)
≤59	72 (5.6)	8 (5.3)	28 (5.0)	5 (1.7)
Household income, n (%)				
Low (0–39 percentile)	605 (46.8)	47 (31.3)	219 (39.0)	111 (38.1)
Middle (40–79 percentile)	441 (34.1)	66 (44.0)	208 (37.1)	101 (34.7)
High (80–100 percentile)	247 (19.1)	37 (24.7)	134 (23.9)	79 (27.2)
Smoking, n (%)				

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Never smoker	1063 (82.2)	105 (70.0)	432 (77.0)	195 (67.0)
Ex-smoker	147 (11.4)	38 (25.3)	86 (15.3)	66 (22.7)
Current smoker	83 (6.4)	7 (4.7)	53 (7.7)	30 (10.3)
Alcoholic drinks, days per week, n (%)				
<1	1041 (80.5)	98 (65.3)	396 (70.7)	190 (65.5)
1–2	179 (13.8)	40 (27.7)	125 (70.7)	81 (27.9)
3–4	53 (4.1)	8 (5.3)	29 (5.2)	13 (4.5)
≥5	20 (1.6)	4 (2.7)	10 (1.8)	6 (2.1)
Use of medication, n (%)				
Medication for hypertension, n (%)	243 (18.8)	18 (12.0)	115 (20.5)	46 (15.8)
Medication for dyslipidemia, n (%)	67 (5.2)	10 (6.7)	35 (6.2)	11 (3.8)

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Medication for diabetes mellitus, n (%)	122 (9.4)	10 (6.7)	49 (8.7)	23 (7.9)
Medication for cardiovascular disease, n (%)	27 (2.1)	4 (2.7)	8 (1.4)	5 (1.7)
Severe COVID-19[*], n (%)	273 (21.1)	25 (16.7)	109 (19.4)	39 (13.4)
Model 1[§] (age and sex adjusted)	1.0 (ref)	0.84 (0.57 to 1.23)	0.88 (0.70 to 1.09)	**0.65 (0.46 to 0.90)**
Model 2[‡] (fully adjusted)	1.0 (ref)	0.87 (0.58 to 1.26)	0.90 (0.72 to 1.10)	**0.66 (0.47 to 0.90)**
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	0.85 (0.58 to 1.24)	0.88 (0.71 to 1.09)	**0.65 (0.46 to 0.90)**
COVID-19 related death, n (%)	32 (2.5)	0 (0.0)	11 (2.0)	2 (0.69)
Model 1[§] (age and sex adjusted)	1.0 (ref)	NA	0.71 (0.36 to 1.42)	0.26 (0.07 to 1.19)
Model 2[‡] (fully adjusted)	1.0 (ref)	NA	0.71 (0.35 to 1.42)	0.28 (0.06 to 1.20)
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	NA	0.71 (0.35 to 1.42)	0.26 (0.07 to 1.20)
Length of stay in hospital, mean (SD)	27.4 (15.3)	26.3 (14.4)	26.7 (15.4)	25.0 (13.6)

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Fully adjusted mean difference ‡(95% CI)	1.0 (ref)	-0.68 (3.28 to 1.89)	-0.57 (-2.06 to 0.92)	**-2.08 (-4.04 to -0.14)**

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; DAGs, directed acyclic graphs; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation.

[*] Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

[§] Model 1: adjusted for age (20−39, 40−59, and ≥60 years) and sex.

[‡] Model 2: adjusted for the age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other areas); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

[‖] Model 3: adjusted for potential confounders selected by DAGs (age; sex; region of residence; household income; smoking; and alcoholic drinks).

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Numbers in bold indicate significant differences ($P < 0.05$).

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Table S4. Baseline characteristics of patients who performed the SARS-CoV-2 testing stratified by MET score in the Korean nationwide

cohort (cohort C)

Characteristic	Entire cohort	Physical activity level, MET min/week			
		Inactive	Insufficiently active	Active	Highly Active
		(MET, 0)	(MET, 1 to <500)	(MET, 500 to <1000)	(MET, ≥ 1000)
Total, n (%)	76,395 (100.0)	33,263 (43.5)	12,650 (16.6)	9689 (12.7)	20,793 (27.2)
Age, years, n (%)					
20-39	25,614 (33.5)	9271 (27.9)	5310 (42.0)	3611 (37.3)	7422 (35.7)
40-59	28,856 (37.8)	12,410 (37.3)	5143 (41.7)	3738 (38.6)	7565 (36.4)
≥ 60	21,925 (28.7)	11,582 (34.8)	2197 (17.4)	2340 (24.2)	5806 (27.9)
Sex, n (%)					
Male	37,272 (48.8)	14,770 (44.4)	5887 (46.5)	4698 (48.5)	11,917 (57.3)

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Female	39,123 (51.2)	18,493 (55.6)	6763 (53.5)	4991 (51.5)	8876 (42.7)
Region of residence, n (%)					
Seoul Capital Area	34,149 (44.7)	14,747 (44.3)	5933 (46.9)	4342 (44.8)	9127 (43.9)
Daegu/Gyeongbuk area	14,910 (19.5)	6912 (20.8)	2258 (17.9)	1866 (19.3)	3874 (18.6)
Other area	27,336 (35.8)	11,604 (34.9)	4459 (35.3)	3481 (35.9)	7792 (37.5)
Charlson comorbidity index, n (%)					
0	44,854 (58.7)	17,389 (52.3)	8522 (67.4)	5962 (61.5)	12,398 (59.6)
1	9361 (12.3)	5963 (17.9)	2075 (16.4)	1645 (17.0)	3520 (16.9)
≥ 2	22,180 (29.0)	9911 (29.8)	2053 (16.2)	2082 (21.5)	4875 (23.5)
History of diabetes mellitus, n (%)	6518 (8.5)	3386 (10.2)	676 (5.3)	712 (7.4)	1744 (8.4)
History of tuberculosis, n (%)	1585 (2.1)	686 (2.1)	285 (2.3)	183 (1.9)	431 (2.1)

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History of stroke, n (%)	1038 (1.4)	586 (1.8)	94 (0.7)	106 (1.1)	252 (1.2)
History of cardiovascular disease, n (%)	2357 (3.1)	1283 (3.9)	228 (1.8)	247 (2.6)	599 (2.9)
History of hypertension, n (%)	14,528 (19.0)	7348 (22.1)	1665 (13.2)	1681 (17.4)	3834 (18.4)
History of dyslipidemia, n (%)	5355 (7.0)	2557 (7.7)	740 (5.9)	682 (7.0)	1376 (6.6)
Body mass index, kg/m^2, n (%)					
Mean (SD)	23.9 (3.8)	23.9 (3.8)	23.8 (3.7)	22.9 (3.8)	22.9 (3.9)
<25	49,286 (64.5)	21,534 (64.7)	8478 (67.0)	6239 (64.4)	13,035 (62.7)
25–30	22,453 (29.4)	9702 (29.2)	3439 (27.2)	2842 (29.3)	6470 (31.1)
≥30	4656 (6.1)	2027 (6.1)	733 (5.8)	608 (6.3)	1288 (6.2)
Systolic blood pressure, mmHg, mean (SD)	121.2 (14.8)	121.2 (14.8)	121.1 (14.4)	121.6 (13.6)	120.8 (13.7)
Diastolic blood pressure, mmHg, mean (SD)	74.9 (10.0)	74.9 (10.0)	74.9 (9.9)	75.0 (9.89)	74.8 (9.7)

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Fasting blood glucose, mg/dL, mean (SD)	99.4 (24.7)	99.4 (24.7)	97.9 (21.3)	99.8 (24.3)	98.2 (22.0)
Serum total cholesterol, mg/dL, mean (SD)	191.4 (40.4)	191.4 (40.4)	191.9 (38.4)	190.5 (39.6)	191.4 (38.4)
Glomerular filtration rate, ml/min, n (%)					
≥90	40,449 (52.9)	17,366 (52.2)	7233 (57.2)	5191 (53.6)	10,659 (51.3)
60-89	31,051 (40.6)	13,037 (39.2)	4938 (39.0)	4021 (41.5)	9055 (43.6)
≤59	4580 (6.0)	2860 (8.6)	479 (3.8)	477 (4.9)	1079 (5.2)
Household income, n (%)					
Low (0–39 percentile)	21,427 (28.4)	11,874 (35.7)	3230 (25.5)	2825 (29.2)	6584 (31.7)
Middle (40–79 percentile)	33,482 (43.8)	12,715 (38.2)	5397 (42.7)	3953 (40.8)	8331 (40.1)
High (80–100 percentile)	21,486 (28.1)	8674 (26.1)	4023 (31.8)	2911 (30.0)	5878 (28.3)
Smoking, n (%)					

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Never smoker	50,227 (65.7)	22,538 (67.8)	8584 (67.9)	6507 (67.2)	12,598 (60.6)
Ex-smoker	12,492 (16.4)	4715 (14.2)	2072 (16.4)	1597 (16.5)	4108 (19.8)
Current smoker	13,676 (17.9)	6010 (18.1)	1994 (15.8)	1585 (16.4)	4087 (19.7)
Alcoholic drinks, days per week, n (%)					
<1	47,769 (62.5)	22,169 (66.7)	7482 (59.2)	5933 (61.2)	12,287 (59.1)
1–2	20,375 (26.7)	7606 (22.9)	3865 (30.6)	2793 (28.8)	6111 (29.4)
3–4	6074 (8.0)	2448 (7.4)	1078 (8.5)	764 (7.9)	1784 (8.6)
≥5	2075 (2.7)	1040 (3.1)	225 (1.8)	199 (2.1)	611 (2.9)
Use of medication, n (%)					
Medication for hypertension, n (%)	13,663 (17.9)	6966 (20.9)	1524 (12.1)	1573 (16.2)	3600 (17.3)
Medication for dyslipidemia, n (%)	4450 (5.8)	2189 (6.6)	547 (4.3)	562 (5.8)	1152 (5.5)

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Medication for diabetes mellitus, n (%)	6080 (8.0)	3174 (9.5)	614 (4.9)	668 (6.9)	1624 (7.8)
Medication for cardiovascular disease, n (%)	2153 (2.8)	1178 (3.5)	196 (1.6)	233 (2.4)	546 (2.6)

Abbreviations: MET, metabolic equivalent of task; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation.

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Table S5. Adjusted relative risks (95% confidence intervals) of SARS-CoV-2 infection associated with study patients stratified by MET score

(cohort C)

Event	Physical activity level, MET min/week			
	Inactive	Insufficiently active	Active	Highly Active
	(MET, 0)	(MET, 1 to <500)	(MET, 500 to <1000)	(MET, ≥ 1000)
COVID-19, n (%)	1087/33,263 (3.3)	344/12,650 (2.7)	249/9689 (2.6)	615/20,793 (3.0)
Adjusted RR (95% CI)				
Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.82 (0.71 to 0.94)**	**0.75 (0.63 to 0.88)**	0.90 (0.81 to 1.01)
Model 2[§] (fully adjusted)	1.0 (ref)	0.91 (0.79 to 1.04)	**0.78 (0.66 to 0.92)**	0.94 (0.85 to 1.05)
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	**0.86 (0.76 to 0.99)**	0.77 (0.65 to 0.90)	0.95 (0.85 to 1.05)
Severe COVID-19[‡], n (%)	239/33,263 (0.72)	58/12,650 (0.46)	39/9689 (0.40)	110/20,793 (0.53)

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Adjusted RR (95% CI)

Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.67 (0.45 to 0.96)**	**0.62 (0.42 to 0.89)**	**0.75 (0.57 to 0.97)**
Model 2[§] (fully adjusted)	1.0 (ref)	0.78 (0.53 to 1.12)	**0.62 (0.43 to 0.90)**	0.79 (0.61 to 1.03)
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	0.75 (0.51 to 1.08)	**0.63 (0.43 to 0.90)**	0.80 (0.61 to 1.03)

COVID-19 related death, n (%)   27/33,263 (0.07)   5/12,650 (0.05)   1/9689 (0.01)   12/20,793 (0.06)

Adjusted RR (95% CI)

Model 1[*] (age and sex adjusted)	1.0 (ref)	0.61 (0.15 to 1.99)	**0.12 (0.02 to 0.94)**	0.75 (0.40 to 1.49)
Model 2[§] (fully adjusted)	1.0 (ref)	0.81 (0.22 to 2.42)	**0.17 (0.07 to 0.98)**	0.79 (0.42 to 1.59)
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	0.71 (0.18 to 2.15)	**0.13 (0.02 to 0.95)**	0.77 (0.41 to 1.54)

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; DAGs, directed acyclic graphs; MET, metabolic equivalent of task;

RR, relative risk; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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* Model 1: adjusted for age (20−39, 40−59, and ≥60 years) and sex.

§ Model 2: adjusted for the age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other areas); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

‖ Model 3: adjusted for potential confounders selected by DAGs (age; sex; region of residence; household income; smoking; and alcoholic drinks).

‡ Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S6. Propensity score-matched baseline covariates and adjusted relative risks (95% confidence intervals) of SARS-CoV-2 infection, severe COVID-19 outcomes, and COVID-19 related death associated with study patients who engaged in physical activities according to MET score (patients with insufficient aerobic and muscle strengthening versus those with aerobic and muscle strengthening; propensity score matched C)

Characteristic	Types of physical activity		SMD
	Insufficient physical activity	Sufficient physical activity	
	(MET, 0 to 500)	(MET, $\geq$ 500)	
Total, n (%)	29,993	29,993	
Age, years, n (%)			0.021
20-39	9158 (30.5)	8967 (29.9)	
40-59	13,763 (45.9)	14,136 (47.1)	
$\geq$ 60	9082 (30.3)	9045 (30.2)	
Sex, n (%)			0.025

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Male	13,763 (45.9)	14,136 (47.1)	
Female	16,230 (54.1)	15,857 (52.9)	
Region of residence, n (%)			0.032
Seoul Capital Area	13,382 (44.6)	14,029 (46.8)	
Daegu/Gyeongbuk area	6188 (20.6)	5744 (19.2)	
Other area	10,423 (34.8)	10,220 (34.1)	
Charlson comorbidity index, n (%)			0.016
0	16,928 (56.4)	17,279 (57.6)	
1	5328 (17.8)	5041 (16.8)	
≥ 2	7737 (25.8)	7673 (25.6)	
History of diabetes mellitus, n (%)	2548 (8.5)	2655 (8.9)	0.013

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History of tuberculosis, n (%)	599 (2.0)	633 (2.1)	0.008
History of stroke, n (%)	337 (1.1)	390 (1.3)	0.015
History of cardiovascular disease, n (%)	851 (2.8)	920 (3.1)	0.003
History of hypertension, n (%)	5801 (19.3)	5837 (19.5)	0.013
History of dyslipidemia, n (%)	2107 (7.0)	2174 (7.3)	0.009
Body mass index, kg/m^2, n (%)			0.016
<25	19,692 (65.7)	19,939 (66.5)	
25–30	8579 (28.6)	8373 (27.9)	
≥30	1722 (5.7)	1681 (5.6)	
Systolic blood pressure, mmHg, mean (SD)	121.3 (15.2)	121.1 (14.5)	0.014
Diastolic blood pressure, mmHg, mean (SD)	74.9 (10.2)	74.7 (9.8)	0.022

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Fasting blood glucose, mg/dL, mean (SD)	99.4 (25.3)	99.6 (24.3)	0.005
Serum total cholesterol, mg/dL, mean (SD)	191.8 (40.5)	190.7 (39.4)	0.027
Glomerular filtration rate, ml/min, n (%)			0.061
≥90	16,119 (53.7)	16,841 (56.2)	
60-89	11,784 (39.3)	11,475 (38.3)	
≤59	2090 (7.0)	1677 (5.6)	
Household income, n (%)			<0.001
Low (0–39 percentile)	10,113 (33.7)	10,185 (34.0)	
Middle (40–79 percentile)	11,799 (39.3)	11,635 (38.8)	
High (80–100 percentile)	8081 (26.9)	8173 (27.3)	
Smoking, n (%)			0.052

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Never smoker	20,287 (67.6)	19,272 (64.3)	
Ex-smoker	4322 (14.4)	5139 (17.1)	
Current smoker	5384 (18.0)	5582 (18.6)	
Alcoholic drinks, days per week, n (%)			0.042
<1	19,601 (65.4)	18,525 (61.8)	
1–2	7200 (24.0)	8212 (27.4)	
3–4	2292 (7.6)	2535 (8.5)	
≥5	900 (3.0)	721 (2.4)	
Use of medication, n (%)			
Medication for hypertension, n (%)	5493 (18.3)	5485 (18.3)	0.003
Medication for dyslipidemia, n (%)	1776 (5.9)	1821 (6.1)	0.006

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Medication for diabetes mellitus, n (%)	2386 (8.0)	2485 (8.3)	0.012
Medication for cardiovascular disease, n (%)	782 (2.6)	845 (2.8)	0.013
COVID-19, n (%)	991 (3.3)	852 (2.8)	
Model 1* (age and sex adjusted)	1.0 (ref)	**0.87 (0.80 to 0.95)**	
Model 2§ (fully adjusted)	1.0 (ref)	**0.90 (0.83 to 0.99)**	
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	**0.88 (0.80 to 0.96)**	
Severe COVID-19‡, n (%)	209 (0.70)	146 (0.49)	
Model 1* (age and sex adjusted)	1.0 (ref)	**0.71 (0.57 to 0.87)**	
Model 2§ (fully adjusted)	1.0 (ref)	**0.77 (0.63 to 0.95)**	
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	**0.72 (0.58 to 0.89)**	
COVID-19 related death, n (%)	23 (0.07)	11 (0.04)	

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Model 1* (age and sex adjusted)	1.0 (ref)	**0.48 (0.24 to 0.98)**
Model 2§ (fully adjusted)	1.0 (ref)	0.51 (0.26 to 1.01)
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	**0.49 (0.24 to 0.99)**

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; DAGs, directed acyclic graphs; MET, metabolic equivalent of task; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation; SMD, standardized mean difference.

* Model 1: adjusted for age (20−39, 40−59, and ≥60 years) and sex.

§ Model 2: adjusted for the age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other areas); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

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|| Model 3: adjusted for potential confounders selected by DAGs (age; sex; region of residence; household income; smoking; and alcoholic drinks).

‡ Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

An SMD of less than 0.1 indicates no major imbalance. All SMD values were less than 0.07 in the propensity-score-matched cohort.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S7. Baseline characteristics of patients who performed the SARS-CoV-2 testing and received the general health examination (2015-2020) stratified by MET score in the Korean nationwide cohort (cohort D)

Characteristic	Entire cohort	Physical activity level, MET min/week			
		Inactive (MET, 0)	Insufficiently active (MET, 1 to <500)	Active (MET, 500 to <1000)	Highly Active (MET, ≥ 1000)
Total, n (%)	118,768	22,811 (19.2)	50,052 (42.1)	25,932 (21.8)	19,973 (16.8)
Age, years (SD)					
20-59	74,912 (63.1)	11,248 (49.3)	32,227 (64.3)	18,966 (73.2)	12,471 (62.4)
60-69	19,284 (16.2)	4443 (19.5)	7727 (15.4)	3621 (14.0)	3493 (17.5)
70-79	15,030 (12.7)	3761 (16.5)	6112 (12.2)	2342 (9.0)	2815 (14.1)
≥ 80	9542 (8.0)	3359 (14.7)	3986 (8.0)	1003 (3.9)	1194 (6.0)
Sex, n (%)					

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Male	56,766 (47.8)	10,128 (44.4)	22,293 (44.5)	13,132 (50.6)	11,213 (56.1)
Female	62,002 (52.2)	12,683 (55.6)	27,759 (55.5)	12,800 (49.4)	8760 (43.9)
Region of residence, n (%)					
Rural	42,804 (36.0)	9306 (40.8)	17,680 (35.3)	8743 (33.7)	7075 (35.4)
Urban	75,964 (64.0)	13,505 (59.2)	32,372 (64.7)	17,189 (66.3)	12,898 (64.6)
Charlson comorbidity index, n (%)					
0	53,793 (45.3)	7663 (33.6)	23,114 (46.2)	13,942 (53.8)	9074 (45.4)
1	17,198 (14.5)	3305 (14.5)	7271 (14.5)	3782 (14.6)	2840 (14.2)
≥ 2	47,777 (40.2)	11,843 (51.9)	19,667 (39.3)	8208 (31.7)	8059 (40.4)
History of diabetes mellitus, n (%)	11,649 (9.8)	2974 (13.0)	4808 (9.6)	1833 (7.1)	2034 (10.2)
History of tuberculosis, n (%)	1860 (1.6)	294 (1.3)	812 (1.6)	444 (1.7)	310 (1.6)
History of stroke, n (%)	1867 (1.6)	584 (2.6)	758 (1.5)	269 (1.0)	256 (1.3)

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History of cardiovascular disease, n (%)	4895 (4.1)	1332 (5.8)	1986 (4.0)	771 (3.0)	806 (4.0)
Body mass index, kg/m², n (%)					
<25	77,882 (65.6)	14,651 (64.2)	33,221 (66.4)	17,168 (66.2)	12,842 (64.3)
25–30	34,289 (28.9)	6763 (29.7)	14,129 (28.2)	7326 (28.3)	6071 (30.4)
≥30	6597 (5.6)	1397 (6.1)	2702 (5.4)	1438 (5.6)	1060 (5.3)
Systolic blood pressure, mmHg, mean (SD)	121.9 (15.1)	123.5 (16.0)	121.4 (15.2)	120.8 (14.4)	122.6 (14.6)
Diastolic blood pressure, mmHg, mean (SD)	75.0 (10.0)	75.5 (10.1)	74.8 (10.0)	74.9 (10.0)	75.2 (9.8)
Fasting blood glucose, mg/dL, mean (SD)	100.5 (27.8)	103.5 (31.8)	100.2 (27.9)	98.5 (23.9)	100.4 (26.8)
Serum total cholesterol, mg/dL, mean (SD)	190.4 (39.6)	189.8 (40.7)	190.8 (40.0)	191.0 (37.5)	189.2 (39.8)
Serum LDL, mg/dL, mean (SD)	109.3 (36.5)	109.2 (38.1)	109.6 (36.0)	109.7 (35.0)	108.4 (37.6)
Serum HDL, mg/dL, mean (SD)	56.5 (15.5)	54.7 (15.06)	56.5 (15.4)	57.4 (16.1)	57.4 (15.4)
Glomerular filtration rate, ml/min, mean (SD)					

≥90	59,909 (50.4)	10,493 (46.0)	25,581 (51.1)	14,071 (54.3)	9764 (48.9)
60-89	51,070 (43.0)	10,025 (44.0)	21,255 (42.5)	10,737 (41.4)	9053 (45.3)
≤59	7789 (6.6)	2293 (10.1)	3216 (6.4)	1124 (4.3)	1156 (5.8)
Household income, n (%)					
Low (0–39 percentile)	28,526 (24.0)	6766 (29.7)	12,036 (24.1)	5260 (20.3)	4464 (22.4)
Middle (40–79 percentile)	44,525 (37.5)	8220 (36.0)	18,764 (37.5)	10,039 (38.7)	7502 (37.6)
High (80–100 percentile)	45,717 (38.5)	7825 (34.3)	19,252 (38.5)	10,633 (41.0)	8007 (40.1)
Smoking, n (%)					
Never smoker	77,778 (65.5)	15,532 (68.1)	33,385 (66.7)	16,580 (63.9)	12,281 (61.5)
Ex-smoker	19,775 (16.7)	3012 (13.2)	7882 (15.8)	4755 (18.3)	4126 (20.7)
Current smoker	21,215 (17.9)	4267 (18.7)	8785 (17.6)	4597 (17.7)	3566 (17.9)

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Alcoholic drinks, days per week, n (%)					
<1	66,717 (56.2)	15,662 (68.7)	28,283 (56.5)	12,364 (47.7)	10,408 (52.1)
1–2	37,863 (31.9)	4513 (19.8)	16,068 (32.1)	10,433 (40.2)	6849 (34.3)
3–4	10,106 (8.5)	1593 (7.0)	4112 (8.2)	2458 (9.5)	1943 (9.7)
≥5	4082 (3.4)	1043 (4.6)	1589 (3.2)	677 (2.6)	773 (3.9)
Use of medication, n (%)					
Medication for hypertension, n (%)	24,119 (20.3)	6098 (26.7)	9838 (19.7)	4091 (15.8)	4092 (20.5)
Medication for diabetes mellitus, n (%)	10,945 (9.2)	2817 (12.4)	4541 (9.1)	1689 (6.5)	1898 (9.5)
Medication for cardiovascular disease, n (%)	4467 (3.8)	1229 (5.4)	1823 (3.6)	680 (2.6)	735 (3.7)

Abbreviations: MET, metabolic equivalent of task; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SD, standard deviation.

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Table S8. Adjusted relative risks (95% confidence intervals) of SARS-CoV-2 infection associated with study participants who engaged in physical activities according to MET score (cohort D)

Event	Physical activity level, MET min/week			
	Inactive (MET, 0)	Insufficiently active (MET, 1 to <500)	Active (MET, 500 to <1000)	Highly Active (MET, ≥ 1000)
COVID-19, n (%)	803/22,811 (3.5)	1641/50,052 (3.3)	816/25,932 (3.2)	622/19,973 (3.1)
Adjusted RR (95% CI)				
Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.92 (0.85 to 0.99)**	**0.89 (0.81 to 0.98)**	**0.91 (0.82 to 0.99)**
Model 2[§] (fully adjusted)	1.0 (ref)	**0.89 (0.82 to 0.97)**	**0.85 (0.75 to 0.96)**	**0.85 (0.74 to 0.99)**
Model 3[ǁ] (selected confounders by DAGs)	1.0 (ref)	**0.91 (0.84 to 0.99)**	**0.89 (0.80 to 0.98)**	**0.91 (0.81 to 0.99)**
Severe COVID-19[‡], n (%)	75/22,811 (0.33)	109/50,052 (0.22)	49/25,932 (0.19)	44/19,973 (0.22)

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Adjusted RR (95% CI)				
Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.66 (0.49 to 0.87)**	**0.58 (0.41 to 0.82)**	**0.70 (0.49 to 0.99)**
Model 2[§] (fully adjusted)	1.0 (ref)	**0.65 (0.47 to 0.86)**	**0.54 (0.35 to 0.79)**	**0.66 (0.45 to 0.96)**
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	**0.65 (0.48 to 0.87)**	**0.57 (0.40 to 0.82)**	**0.69 (0.48 to 0.98)**
COVID-19 related death, n (%)	39/22,811 (0.17)	53/50,052 (0.11)	17/25,932 (0.07)	13/19,973 (0.07)
Adjusted RR (95% CI)				
Model 1[*] (age and sex adjusted)	1.0 (ref)	**0.61 (0.40 to 0.93)**	**0.37 (0.21 to 0.67)**	**0.39 (0.21 to 0.72)**
Model 2[§] (fully adjusted)	1.0 (ref)	**0.60 (0.40 to 0.93)**	**0.35 (0.20 to 0.64)**	**0.37 (0.19 to 0.71)**
Model 3[‖] (selected confounders by DAGs)	1.0 (ref)	**0.61 (0.40 to 0.93)**	**0.36 (0.20 to 0.67)**	**0.39 (0.20 to 0.72)**

Abbreviations here: CI, confidence interval; COVID-19, coronavirus disease; DAGs, directed acyclic graphs; MET, metabolic equivalent of task; RR, relative risk; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

[*] Model 1: adjusted for age (20-59, 60-69, 70-79, and ≥ 80 years) and sex.

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§ Model 2: adjusted for the age; sex; region of residence (rural and urban); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

‖ Model 3: adjusted for potential confounders selected by DAGs (age; sex; region of residence; household income; smoking; and alcoholic drinks).

‡ Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S9. Propensity score-matched baseline covariates and adjusted relative risks (95% confidence intervals) of SARS-CoV-2 infection associated with study participants who engaged in physical activities according MET score (insufficient physical activity versus sufficient physical activity; propensity score matched cohort D)

Characteristic	Insufficient physical activity (MET, 0 to 500)	Sufficient physical activity (MET, ≥ 500)	SMD
Total, n (%)	11,930	11,930	
Age, years (SD)			0.002
20-59	8764 (73.5)	8733 (73.2)	
60-69	1652 (13.9)	1601 (13.4)	
70-79	966 (8.1)	1130 (9.5)	
≥ 80	548 (5.6)	466 (3.9)	
Sex, n (%)			0.004

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Male	6090 (51.1)	6115 (51.3)	
Female	5840 (49.0)	5815 (48.7)	
Region of residence, n (%)			0.003
Rural	4032 (33.8)	4016 (33.7)	
Urban	7898 (66.2)	7914 (66.3)	
Charlson comorbidity index, n (%)			0.006
0	6214 (52.1)	6447 (54.0)	
1	1789 (15.0)	1735 (14.5)	
≥2	3927 (32.9)	3748 (31.4)	
History of diabetes mellitus, n (%)	827 (6.9)	855 (7.2)	0.008
History of tuberculosis, n (%)	193 (1.6)	199 (1.7)	0.004
History of stroke, n (%)	103 (0.9)	117 (1.0)	0.010

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History of cardiovascular disease, n (%)	348 (2.9)	344 (2.9)	0.002
Body mass index, kg/m^2, n (%)			<0.001
< 25	7800 (65.4)	7845 (65.8)	
25–30	3455 (29.0)	3390 (28.4)	
≥30	675 (5.7)	695 (5.8)	
Systolic blood pressure, mmHg, mean (SD)	120.8 (14.4)	120.8 (14.4)	0.005
Diastolic blood pressure, mmHg, mean (SD)	74.8 (9.9)	74.8 (9.9)	0.014
Fasting blood glucose, mg/dL, mean (SD)	98.7 (24.7)	98.7 (24.7)	0.001
Serum total cholesterol, mg/dL, mean (SD)	190.5 (37.2)	190.5 (37.2)	0.010
Serum LDL, mg/dL, mean (SD)	109.4 (36.2)	109.4 (36.2)	0.008
Serum HDL, mg/dL, mean (SD)	57.1 (14.7)	57.1 (14.7)	0.012
Glomerular filtration rate, ml/min, mean (SD)			0.002

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≥90	6502 (54.5)	6594 (55.3)	
60-89	4914 (41.2)	4836 (40.5)	
≤59	514 (4.3)	500 (4.2)	
Household income, n (%)			0.007
Low (0–39 percentile)	2517 (21.1)	2411 (20.2)	
Middle (40–79 percentile)	4590 (38.5)	4747 (39.8)	
High (80–100 percentile)	4823 (40.4)	4772 (40.0)	
Smoking, n (%)			0.007
Never smoker	7654 (64.2)	7590 (63.6)	
Ex-smoker	2033 (17.0)	2095 (17.6)	
Current smoker	2243 (18.8)	2245 (18.8)	

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Alcoholic drinks, days per week, n (%)			0.005
<1	5828 (48.9)	5600 (46.9)	
1–2	4585 (38.4)	4897 (41.1)	
3–4	1122 (9.4)	1109 (9.3)	
≥5	395 (3.3)	324 (2.7)	
Use of medication, n (%)			
Medication for hypertension, n (%)	1795 (15.1)	1807 (15.2)	0.003
Medication for diabetes mellitus, n (%)	776 (6.5)	788 (6.6)	0.004
Medication for cardiovascular disease, n (%)	305 (2.6)	302 (2.5)	0.001
COVID-19, n (%)	429 (3.6)	372 (3.1)	
Model 1* (age and sex adjusted)	1.0 (ref)	**0.86 (0.76 to 0.99)**	

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Model 2§ (fully adjusted)	1.0 (ref)	**0.87 (0.76 to 0.99)**
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	**0.86 (0.76 to 0.99)**
Severe COVID-19, n (%)	40 (0.28)	24 (0.20)
Model 1* (age and sex adjusted)	1.0 (ref)	**0.57 (0.34 to 0.97)**
Model 2§ (fully adjusted)	1.0 (ref)	**0.58 (0.35 to 0.99)**
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	**0.58 (0.35 to 0.98)**
COVID-19 related death, n (%)	21 (0.18)	9 (0.08)
Model 1* (age and sex adjusted)	1.0 (ref)	**0.44 (0.21 to 0.94)**
Model 2§ (fully adjusted)	1.0 (ref)	**0.46 (0.22 to 0.96)**
Model 3‖ (selected confounders by DAGs)	1.0 (ref)	**0.44 (0.21 to 0.94)**

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; MET, metabolic equivalent of task; SARS-CoV-2, severe acute

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respiratory syndrome coronavirus 2; SD, standard deviation.

*Model 1: adjusted for age (20-59, 60-69, 70-79, and ≥ 80 years) and sex.

Abbreviations here: CI, confidence interval; COVID-19, coronavirus disease; DAGs, directed acyclic graphs; MET, metabolic equivalent of task; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; OR, odds ratio.

*Model 1: adjusted for age (20-59, 60-69, 70-79, and ≥ 80 years) and sex.

§ Model 2: adjusted for the age; sex; region of residence (rural and urban); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

‖ Model 3: adjusted for potential confounders selected by DAGs (age; sex; region of residence; household income; smoking; and alcoholic drinks).

‡ Severe COVID-19 consisted of admission to the intensive care unit, invasive ventilation, or death.

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An SMD of less than 0.1 indicates no major imbalance. All SMD values were less than 0.015 in the propensity-score-matched cohort .

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S10. Baseline characteristics of COVID-19 patients who received the general health examination (2015-2020) in the Korean nationwide cohort (total n = 3882; Cohort E)

Characteristic	Physical activity level, MET min/week			
	Inactive	Insufficiently active	Active	Highly Active
	(MET, 0)	(MET, 1 to <500)	(MET, 500 to <1000)	(MET, ≥ 1000)
Total, n (%)	803 (20.7)	1641 (42.3)	816 (21.0)	622 (16.0)
Age, years (SD)				
20-59	424 (52.8)	988 (60.3)	570 (69.9)	381 (61.3)
60-69	231 (28.8)	378 (23.0)	155 (19.0)	146 (23.5)
70-79	85 (10.6)	182 (11.1)	72 (8.8)	76 (12.2)
≥ 80	63 (7.9)	93 (5.7)	19 (2.3)	19 (3.1)
Sex, n (%)				

Male	280 (34.9)	514 (31.3)	350 (42.9)	304 (48.9)
Female	523 (65.1)	1127 (68.7)	466 (57.1)	318 (51.1)
Region of residence, n (%)				
Rural	61 (7.6)	148 (9.0)	92 (11.3)	77 (12.4)
Urban	742 (92.4)	1493 (91.0)	724 (88.7)	545 (87.6)
Charlson comorbidity index, n (%)				
0	326 (40.6)	807 (49.2)	464 (56.9)	312 (50.2)
1	172 (21.4)	284 (17.3)	112 (13.7)	100 (16.1)
≥2	305 (38.0)	550 (33.5)	240 (29.4)	210 (33.8)
History of diabetes mellitus, n (%)	79 (9.8)	155 (9.5)	51 (6.3)	67 (10.8)
History of tuberculosis, n (%)	9 (1.1)	23 (1.4)	12 (1.5)	7 (1.1)
History of stroke, n (%)	14 (1.7)	16 (1.0)	6 (0.7)	6 (1.0)

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History of cardiovascular disease, n (%)	27 (3.4)	32 (2.0)	18 (2.2)	19 (3.1)
Body mass index, kg/m^2, n (%)				
<25	490 (61.0)	1077 (65.6)	545 (66.8)	393 (63.2)
25–30	271 (33.8)	486 (29.6)	235 (28.8)	208 (33.4)
≥30	42 (5.2)	78 (4.8)	36 (4.4)	21 (3.4)
Systolic blood pressure, mmHg, mean (SD)	122.6 (15.6)	120.9 (15.2)	120.5 (15.5)	122.3 (14.2)
Diastolic blood pressure, mmHg, mean (SD)	75.5 (10.2)	74.4 (9.8)	75.0 (10.4)	75.3 (9.5)
Fasting blood glucose, mg/dL, mean (SD)	102.9 (27.8)	100.5 (26.4)	98.9 (20.4)	102.7 (39.3)
Serum total cholesterol, mg/dL, mean (SD)	194.8 (38.2)	196.1 (37.7)	194.0 (38.0)	192.8 (36.4)
Serum LDL, mg/dL, mean (SD)	114.6 (34.0)	115.5 (33.8)	113.4 (33.8)	111.7 (32.9)
Serum HDL, mg/dL, mean (SD)	54.8 (14.7)	56.6 (14.4)	58.5 (28.6)	57.8 (13.9)
Glomerular filtration rate, ml/min, mean (SD)				

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≥90	387 (48.2)	818 (49.9)	398 (48.8)	296 (47.6)
60-89	363 (45.2)	758 (46.2)	390 (47.8)	307 (49.4)
≤59	53 (6.6)	65 (4.0)	28 (3.4)	19 (3.1)
Household income, n (%)				
Low (0–39 percentile)	350 (43.6)	590 (36.0)	251 (30.8)	202 (32.5)
Middle (40–79 percentile)	249 (31.0)	548 (33.4)	291 (35.7)	205 (33.0)
High (80–100 percentile)	204 (25.4)	503 (30.7)	274 (33.6)	215 (34.6)
Smoking, n (%)				
Never smoker	643 (80.1)	1297 (79.0)	610 (74.8)	464 (74.6)
Ex-smoker	95 (11.8)	226 (13.8)	145 (17.8)	106 (17.0)
Current smoker	65 (8.1)	118 (7.2)	61 (7.5)	52 (8.4)

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Alcoholic drinks, days per week, n (%)

<1	623 (77.6)	1165 (71.0)	488 (59.8)	378 (60.8)
1–2	114 (14.2)	360 (21.9)	263 (32.2)	181 (29.1)
3–4	43 (5.4)	87 (5.3)	52 (6.4)	43 (6.9)
≥5	23 (2.9)	29 (1.8)	13 (1.6)	20 (3.2)

Use of medication, n (%)

Medication for hypertension, n (%)	158 (19.7)	301(18.3)	123 (15.1)	110 (17.7)
Medication for diabetes mellitus, n (%)	75 (9.3)	148 (9.0)	47 (5.8)	57 (9.2)
Medication for cardiovascular disease, n (%)	24 (3.0)	28 (1.7)	14 (1.7)	16 (2.6)

Severe COVID-19[*], n (%)	75 (9.3)	109 (6.6)	49 (6.0)	44 (7.1)
Age and sex adjusted RR[§] (95% CI)	1.0 (ref)	**0.73 (0.54 to 0.98)**	**0.67 (0.48 to 0.93)**	0.75 (0.50 to 1.10)

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Fully adjusted RR‡ (95% CI)	1.0 (ref)	**0.73 (0.53 to 0.99)**	**0.68 (0.44 to 0.98)**	0.74 (0.48 to 1.12)
DAG	1.0 (ref)	**0.73 (0.54 to 0.98)**	**0.67 (0.47 to 0.94)**	0.75 (0.49 to 1.10)
COVID-19 related death, n (%)	39 (4.9)	53 (3.2)	17 (2.1)	13 (2.1)
Age and sex adjusted OR§ (95% CI)	1.0 (ref)	0.72 (0.51 to 1.04)	**0.48 (0.29 to 0.80)**	**0.44 (0.24 to 0.81)**
Fully adjusted OR‡ (95% CI)	1.0 (ref)	0.74 (0.49 to 1.06)	**0.49 (0.27 to 0.82)**	**0.43 (0.22 to 0.83)**
DAG	1.0 (ref)	0.72 (0.50 to 1.04)	**0.48 (0.28 to 0.81)**	**0.44 (0.23 to 0.82)**
Length of stay in hospital, mean (SD)	27.5 (16.5)	27.3 (15.1)	24.8 (14.3)	26.1 (14.3)
Fully adjusted mean difference ‡(95% CI)	1.0 (ref)	-0.18 (-1.47 to 1.11)	**-1.85 (-3.63 to -0.05)**	-0.68 (-3.19 to 1.82)

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; MET, metabolic equivalent of task; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; OR, odds ratio.

* Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

§ Model 1: adjusted for age (20-59, 60-69, 70-79, and ≥ 80 years) and sex.

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‡Model 2: adjusted for the age; sex; region of residence (rural and urban); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S11. Age-stratified outcome characteristics in cohort A (total n = 76,395)

Age, years, n (%)	COVID-19	Severe COVID-19[*]	COVID-19 related death,
Total	2295 (100.0)	446 (100.0)	45 (100.0)
20-39	413 (18.0)	30 (6.7)	0 (0.0)
40-59	1095 (47.7)	147 (33.0)	2 (4.4)
≥ 60	787 (34.3)	269 (60.3)	43 (95.6)

Abbreviations: COVID-19, coronavirus disease; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

[*] Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

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Table S12. Bonferroni-Sidak's correction for multiple comparisons in Table 2

Event	Types of physical activity			
	Insufficient aerobic and muscle strengthening	Muscle strengthening only	Aerobic only	Aerobic and muscle strengthening
COVID-19, n (%)	1293/41,293 (3.1)	150/5036 (3.0)	561/18,994 (3.0)	291/11,072 (2.6)
Adjusted RR (95% CI)				
Model 2* (fully adjusted)	1.0 (ref)	1.01 (0.73 to 1.42)	0.92 (0.77 to 1.12)	**0.84 (0.73 to 0.96)**
Significance of model 2	-	No	No	**Yes**
Significance after Bonferroni-Sidak's correction	-	No	No	**Yes**
Severe COVID-19‡, n (%)	273/41,293 (0.66)	25/5036 (0.50)	109/18,994 (0.57)	39/11,072 (0.35)
Model 2* (fully adjusted)	1.0 (ref)	0.93 (0.61 to 1.42)	0.86 (0.69 to 1.08)	**0.42 (0.19 to 0.91)**

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Significance of model 2		No	No	**Yes**
Significance after Bonferroni-Sidak's correction	-	No	No	No
COVID-19 related death, n (%)	32/41,293 (0.08)	0/5036 (0.00)	11/18,994 (0.06)	2/11,072 (0.02)
Model 2[*] (fully adjusted)	1.0 (ref)	NA	0.71 (0.34 to 1.41)	**0.26 (0.07 to 0.99)**
Significance of model 2	-		No	**Yes**
Significance after Bonferroni-Sidak's correction	-	-	No	No

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; RR, relative risk; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

[*] Model 2: adjusted for the age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other areas); Charlson comorbidity index (0, 1, and $\geq$2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the cubic spline function); systolic blood pressure (continuous; using the restricted cubic spline function); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate ($\geq$90, 60−89, and $\leq$59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, $\geq$5 days per week);

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medication for hypertension, diabetes mellitus, and cardiovascular disease.

‡ Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S13. Bonferroni-Sidak's correction for multiple comparisons in Table S5

Event	Physical activity level, MET min/week			
	Inactive (MET, 0)	Insufficiently active (MET, 1 to <500)	Active (MET, 500 to <1000)	Highly Active (MET, ≥ 1000)
COVID-19, n (%)	1087/33,263 (3.3)	344/12,650 (2.7)	249/9689 (2.6)	615/20,793 (3.0)
Model 2[*] (fully adjusted)	1.0 (ref)	0.91 (0.79 to 1.04)	**0.78 (0.66 to 0.92)**	0.94 (0.85 to 1.05)
Significance of model 2	-	No	**Yes**	No
Significance after Bonferroni-Sidak's correction	-	No	**Yes**	No
Severe COVID-19[‡], n (%)	239/33,263 (0.72)	58/12,650 (0.46)	39/9689 (0.40)	110/20,793 (0.53)
Model 2[*] (fully adjusted)	1.0 (ref)	0.78 (0.53 to 1.12)	**0.62 (0.43 to 0.90)**	0.79 (0.61 to 1.03)
Significance of model 2		No	**Yes**	No

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Significance after Bonferroni-Sidak's correction	-	No	**Yes**	No
COVID-19 related death, n (%)	27/33,263 (0.07)	5/12,650 (0.05)	1/9689 (0.01)	12/20,793 (0.06)
Model 2* (fully adjusted)	1.0 (ref)	0.81 (0.22 to 2.42)	**0.17 (0.07 to 0.98)**	0.79 (0.42 to 1.59)
Significance of model 2		No	**Yes**	No
Significance after Bonferroni-Sidak's correction	-	No	**Yes**	No

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; MET, metabolic equivalent of task; RR, relative risk; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

*Model 2: adjusted for the age; sex; region of residence (Seoul Capital Area, Daegu/Gyeongbuk area, and other areas); Charlson comorbidity index (0, 1, and ≥2); history of diabetes mellitus, tuberculosis, stroke, and cardiovascular disease; body mass index (continuous; using the restricted cubic spline function); systolic blood pressure (continuous); diastolic blood pressure (continuous); fasting blood glucose (continuous); serum total cholesterol (continuous); glomerular filtration rate (≥90, 60−89, and ≤59 ml/min); household income (low, middle, and high); smoking (never, ex-, and current); alcoholic drinks (<1, 1−2, 3−4, ≥5 days per week); medication for hypertension, diabetes mellitus, and cardiovascular disease.

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‡ Severe COVID-19 consisted of requirement of oxygen therapy, admission to the intensive care unit, invasive ventilation, or death.

Numbers in bold indicate significant differences ($P < 0.05$).

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Table S14. Previous studies on the association between physical activity and the risk of COVID-19

Title	Study	Country	Setting	Exposure definition (exercise)	Results
Association of Timing and Balance of Physical Activity and Rest/Sleep With Risk of COVID-19: A UK Biobank Study	Rowlands et al (2021)	UK	- UK Biobank - A prospective cohort - Adults age 40-69 years - Total n=91,041 - COVID-19 patients=207	24-hour movement patterns fromAxivity AX3 wrist-worn accelerometers (Axivity, Newcastle, UK)	No association between physical activity and the risk of SARS-CoV-2 positivity and COVID-19 severity.
Inverse Relationship of Maximal Exercise Capacity to Hospitalization Secondary to Coronavirus Disease 2019	Brawner et al (2021)	USA	- Medical chart review - A retrospective cohort - COVID-19 Patients (≥18 years) - COVID-19 patients=246	Exercise tests: 1) the types of electrocardiography only; 2) electrocardiography plus echocardiography; and 3) cardiopulmonary exercise tests.	Beneficial association between maximal exercise capacity and the risk of hospitalization due to COVID-19.
Lifestyle risk factors, inflammatory mechanisms, and COVID-19 hospitalization: A	Hamer et al (2020)	UK	- UK Biobank - A prospective cohort	International Physical Activity Questionnaire short form	Beneficial association between physical activity and the risk of hospitalization due to COVID-19.

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community-based cohort study of 387,109 adults in UK			- Adults age 40-69 years - Total n=387,109 - Hospitalized COVID-19 Patients=760		
Physical inactivity is associated with a higher risk for severe COVID-19 outcomes: a study in 48 440 adult patients	Sallis et al (2021)	USA	- Medical chart review - A retrospective cohort - COVID-19 Patients (≥18 years) - COVID-19 Patients =103,337	Self-reported questionnaire based on the US Physical Activity Guidelines	Beneficial association between physical activity and the risk of COVID-19 severity (hospitalization, ICU admission, and death after COVID-19 diagnosis).

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease; ICU, intensive care unit; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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