



Figure S1. Directed acyclic graph depicting potential causal and non-causal pathways between physical activity and influenza and pneumonia mortality.

Table S1. Hazard Ratios for Influenza and Pneumonia Deaths, by Physical Activity Levels, Stratified by Age Groups

	50–64 Years (n=136 216)		65–74 Years (n=66 709)		≥75 Years (n=56 882)	
	Deaths	aHR ^a (95% CI)	Deaths	aHR ^a (95% CI)	Deaths	aHR ^a (95% CI)
Guideline						
Neither ^b	181	1.00 [ref]	233	1.00 [ref]	626	1.00 [ref]
Aerobic only ^c	34	0.51 (0.32 to 0.80)	57	0.59 (0.42 to 0.82)	122	0.69 (0.54 to 0.88)
Strength only ^d	9	1.04 (0.46 to 2.34)	11	0.88 (0.41 to 1.90)	41	1.27 (0.88 to 1.85)
Both ^e	10	0.39 (0.19 to 0.81)	20	0.58 (0.35 to 0.97)	34	0.53 (0.35 to 0.79)
MVPA, min/wk						
<10	147	1.00 [ref]	197	1.00 [ref]	514	1.00 [ref]
10–149	43	0.88 (0.58 to 1.34)	47	0.58 (0.38 to 0.86)	153	0.85 (0.69 to 1.04)
150–300	19	0.52 (0.29 to 0.93)	29	0.47 (0.30 to 0.73)	79	0.70 (0.54 to 0.90)
301–600	11	0.34 (0.17 to 0.68)	26	0.56 (0.32 to 0.97)	40	0.45 (0.31 to 0.64)
>600	14	0.55 (0.26 to 1.20)	22	0.46 (0.28 to 0.76)	37	0.65 (0.41 to 1.03)
MSA, episodes/wk						
<2	215	1.00 [ref]	290	1.00 [ref]	748	1.00 [ref]
2	2	0.32 (0.08 to 1.33)	4	0.53 (0.19 to 1.52)	8	0.57 (0.27 to 1.18)
3	6	0.79 (0.32 to 1.97)	10	1.16 (0.57 to 2.35)	18	0.99 (0.56 to 1.75)
4–6	0	--	10	1.78 (0.81 to 3.92)	7	0.62 (0.27 to 1.42)
≥7	11	1.97 (0.91 to 4.25)	7	0.72 (0.33 to 1.58)	42	1.45 (0.99 to 2.12)

aHR, adjusted hazard ratio; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity.

Sample adults ≥50 years who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019.

^aAdjusted for sex; race/ethnicity; education; marital status; smoking status; alcohol consumption; body mass index; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; and influenza and pneumococcal vaccination status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^bReported <150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^cReported ≥150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^dReported ≥2 episodes/wk of muscle-strengthening activity and <150 min/wk of moderate-intensity equivalent physical activity.

^eReported ≥150 min/wk of moderate-intensity equivalent physical activity and ≥2 episodes/wk of muscle-strengthening activity.

Table S2. Hazard Ratios for Influenza and Pneumonia Deaths, by Physical Activity Levels, Restricted to Those Without Any Baseline Medical Conditions

	Deaths	No. (weighted %)	Person-Years	Unadjusted HR (95% CI)	Adjusted HR ^a (95% CI)	Adjusted HR ^b (95% CI)
Guideline						
Neither ^c	248	143 954 (46.0)	1 692 388	1.00 [ref]	1.00 [ref]	1.00 [ref]
Aerobic only ^d	65	85 473 (28.6)	935 412	0.43 (0.31 to 0.59)	0.55 (0.40 to 0.76)	0.56 (0.37 to 0.85)
Strength only ^e	17	10 082 (3.4)	115 422	0.91 (0.52 to 1.59)	1.09 (0.62 to 1.90)	1.02 (0.49 to 2.09)
Both ^f	26	63 604 (22.0)	671 672	0.25 (0.16 to 0.41)	0.53 (0.32 to 0.88)	0.62 (0.29 to 1.35)
MVPA, min/wk						
<10	209	97 601 (30.4)	1 172 197	1.00 [ref]	1.00 [ref]	1.00 [ref]
10–149	56	56 435 (19.0)	635 613	0.51 (0.36 to 0.72)	0.68 (0.47 to 0.98)	0.59 (0.36 to 0.96)
150–300	40	48 054 (16.3)	529 713	0.35 (0.24 to 0.52)	0.55 (0.37 to 0.82)	0.49 (0.29 to 0.85)
301–600	24	51 946 (17.6)	556 921	0.25 (0.15 to 0.40)	0.41 (0.25 to 0.69)	0.43 (0.21 to 0.87)
>600	27	49 077 (16.7)	520 450	0.28 (0.17 to 0.45)	0.45 (0.27 to 0.76)	0.42 (0.18 to 0.98)
MSA, episodes/wk						
<2	313	229 427 (74.6)	2 627 800	1.00 [ref]	1.00 [ref]	1.00 [ref]
2	4	17 720 (6.1)	187 679	0.18 (0.06 to 0.49)	0.51 (0.18 to 1.47)	0.91 (0.26 to 3.18)
3	18	25 139 (8.7)	277 393	0.65 (0.38 to 1.13)	1.69 (0.97 to 2.94)	1.48 (0.44 to 4.98)
4–6	5	17 711 (6.2)	183 673	0.13 (0.05 to 0.38)	0.43 (0.15 to 1.26)	1.01 (0.40 to 2.54)
≥7	16	13 116 (4.4)	138 349	0.80 (0.45 to 1.41)	1.20 (0.66 to 2.17)	1.17 (0.57 to 2.37)

HR, hazard ratio; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity.

Sample adults who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019. Restricted to those without baseline presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, or asthma (N=303 113).

^aAdjusted for sex, age, race/ethnicity, education, and marital status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^bAdjusted for sex, age, race/ethnicity, education, marital status, smoking status, alcohol consumption, body mass index, and influenza and pneumococcal vaccination status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^cReported <150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^dReported ≥150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^eReported ≥2 episodes/wk of muscle-strengthening activity and <150 min/wk of moderate-intensity equivalent physical activity.

^fReported ≥150 min/wk of moderate-intensity equivalent physical activity and ≥2 episodes/wk of muscle-strengthening activity.

Table S3. Hazard Ratios for Influenza and Pneumonia Deaths, by Physical Activity Levels, Restricted to Never Smokers

	Deaths	No. (weighted %)	Person-Years	Unadjusted HR (95% CI)	Adjusted HR ^a (95% CI)	Adjusted HR ^b (95% CI)
Guideline						
Neither ^c	571	170 051 (48.5)	1 794 912	1.00 [ref]	1.00 [ref]	1.00 [ref]
Aerobic only ^d	122	88 039 (27.1)	894 531	0.44 (0.35 to 0.56)	0.69 (0.54 to 0.88)	0.73 (0.57 to 0.94)
Strength only ^e	24	11 705 (3.5)	119 419	1.34 (0.88 to 2.05)	0.67 (0.42 to 1.09)	0.71 (0.44 to 1.15)
Both ^f	34	64 268 (20.8)	632 766	0.16 (0.11 to 0.23)	0.44 (0.29 to 0.65)	0.48 (0.33 to 0.72)
MVPA, min/wk						
<10	481	115 830 (32.0)	1 235 454	1.00 [ref]	1.00 [ref]	1.00 [ref]
10–149	114	65 926 (20.1)	678 877	0.38 (0.31 to 0.48)	0.60 (0.47 to 0.75)	0.63 (0.50 to 0.80)
150–300	72	52 365 (16.3)	535 044	0.32 (0.24 to 0.42)	0.63 (0.47 to 0.84)	0.67 (0.50 to 0.90)
301–600	47	53 052 (16.7)	531 173	0.21 (0.15 to 0.29)	0.52 (0.36 to 0.76)	0.56 (0.39 to 0.81)
>600	37	46 890 (14.9)	461 080	0.23 (0.15 to 0.36)	0.62 (0.38 to 0.99)	0.68 (0.43 to 1.09)
MSA, episodes/wk						
<2	693	258 090 (75.7)	2 689 443	1.00 [ref]	1.00 [ref]	1.00 [ref]
2	9	18 444 (5.9)	182 334	0.15 (0.08 to 0.31)	0.50 (0.24 to 1.01)	0.52 (0.26 to 1.06)
3	14	25 844 (8.3)	263 660	0.21 (0.11 to 0.39)	0.61 (0.32 to 1.16)	0.64 (0.34 to 1.22)
4–6	5	17 999 (5.9)	175 396	0.14 (0.05 to 0.35)	0.46 (0.18 to 1.18)	0.48 (0.19 to 1.21)
≥7	30	13 686 (4.3)	130 795	0.76 (0.52 to 1.13)	1.00 (0.67 to 1.52)	1.00 (0.66 to 1.51)

HR, hazard ratio; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity.

Sample adults who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019. Restricted to those who reported never smoking (N=334 063).

^aAdjusted for sex, age, race/ethnicity, education, and marital status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^bAdjusted for sex; age; race/ethnicity; education; marital status; alcohol consumption; body mass index; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; and influenza and pneumococcal vaccination status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^cReported <150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^dReported ≥150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^eReported ≥2 episodes/wk of muscle-strengthening activity and <150 min/wk of moderate-intensity equivalent physical activity.

^fReported ≥150 min/wk of moderate-intensity equivalent physical activity and ≥2 episodes/wk of muscle-strengthening activity.

Table S4. Hazard Ratios for Influenza and Pneumonia Deaths, by Physical Activity Levels, Restricted to Participants with Normal Body Mass Index at Baseline

	Deaths	No. (weighted %)	Person-Years	Unadjusted HR (95% CI)	Adjusted HR ^a (95% CI)	Adjusted HR ^b (95% CI)
Guideline						
Neither ^c	423	96 524 (45.3)	1 033 430	1.00 [ref]	1.00 [ref]	1.00 [ref]
Aerobic only ^d	118	56 080 (28.3)	598 886	0.52 (0.42 to 0.65)	0.77 (0.61 to 0.98)	0.83 (0.65 to 1.06)
Strength only ^e	35	7725 (3.8)	82 511	1.13 (0.75 to 1.69)	1.31 (0.88 to 1.95)	1.40 (0.94 to 2.09)
Both ^f	37	43 442 (22.6)	454 761	0.20 (0.14 to 0.30)	0.53 (0.36 to 0.77)	0.61 (0.41 to 0.91)
MVPA, min/wk						
<10	350	66 885 (30.5)	712 422	1.00 [ref]	1.00 [ref]	1.00 [ref]
10–149	108	37 364 (18.6)	403 520	0.52 (0.41 to 0.67)	0.77 (0.60 to 0.98)	0.82 (0.64 to 1.05)
150–300	69	31 741 (16.1)	343 469	0.38 (0.29 to 0.49)	0.68 (0.52 to 0.90)	0.74 (0.56 to 0.98)
301–600	44	34 948 (17.9)	369 811	0.25 (0.18 to 0.36)	0.56 (0.38 to 0.81)	0.61 (0.42 to 0.90)
>600	42	32 833 (16.9)	340 366	0.30 (0.20 to 0.44)	0.67 (0.43 to 1.04)	0.74 (0.48 to 1.16)
MSA, episodes/wk						
<2	541	152 604 (73.6)	1 632 315	1.00 [ref]	1.00 [ref]	1.00 [ref]
2	10	12 101 (6.2)	127 321	0.21 (0.11 to 0.41)	0.66 (0.34 to 1.31)	0.72 (0.37 to 1.42)
3	18	17 310 (9.0)	187 472	0.34 (0.20 to 0.59)	0.91 (0.53 to 1.57)	0.97 (0.56 to 1.68)
4–6	10	11 674 (6.2)	120 510	0.27 (0.13 to 0.55)	0.82 (0.40 to 1.71)	0.90 (0.43 to 1.88)
≥7	34	10 082 (5.0)	101 970	1.01 (0.67 to 1.51)	1.25 (0.81 to 1.91)	1.30 (0.85 to 2.00)

HR, hazard ratio; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity.

Sample adults who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019. Restricted to those who reported body mass index in the normal range (N=203 771).

^aAdjusted for sex, age, race/ethnicity, education, and marital status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^bAdjusted for sex; age; race/ethnicity; education; marital status; smoking status; alcohol consumption; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; and influenza and pneumococcal vaccination status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^cReported <150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^dReported ≥150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^eReported ≥2 episodes/wk of muscle-strengthening activity and <150 min/wk of moderate-intensity equivalent physical activity.

^fReported ≥150 min/wk of moderate-intensity equivalent physical activity and ≥2 episodes/wk of muscle-strengthening activity.

Table S5. Hazard Ratios for Influenza and Pneumonia Deaths, by Physical Activity Levels, Excluding Those Who Died Within Two Years of the Interview

	Deaths	No. (weighted %)	Person-Years	Unadjusted HR (95% CI)	Adjusted HR ^a (95% CI)	Adjusted HR ^b (95% CI)
Guideline						
Neither ^c	1001	294 377 (50.0)	3 124 774	1.00 [ref]	1.00 [ref]	1.00 [ref]
Aerobic only ^d	222	151 837 (27.5)	1 570 564	0.45 (0.38 to 0.53)	0.61 (0.51 to 0.72)	0.65 (0.55 to 0.78)
Strength only ^e	65	20 246 (3.6)	208 243	1.05 (0.78 to 1.42)	1.18 (0.88 to 1.59)	1.23 (0.92 to 1.66)
Both ^f	71	100 311 (18.9)	1 016 147	0.21 (0.16 to 0.28)	0.47 (0.35 to 0.63)	0.53 (0.39 to 0.71)
MVPA, min/wk						
<10	817	202 717 (33.5)	2 174 582	1.00 [ref]	1.00 [ref]	1.00 [ref]
10–149	249	111 906 (20.1)	1 158 435	0.56 (0.47 to 0.67)	0.76 (0.64 to 0.91)	0.82 (0.68 to 0.97)
150–300	126	85 327 (15.6)	886 108	0.35 (0.28 to 0.43)	0.55 (0.45 to 0.69)	0.60 (0.48 to 0.75)
301–600	86	86 675 (16.0)	885 849	0.25 (0.19 to 0.32)	0.46 (0.35 to 0.61)	0.51 (0.39 to 0.67)
>600	81	80 146 (14.9)	814 754	0.29 (0.22 to 0.39)	0.54 (0.39 to 0.74)	0.60 (0.44 to 0.83)
MSA, episodes/wk						
<2	1223	446 214 (77.5)	4 695 338	1.00 [ref]	1.00 [ref]	1.00 [ref]
2	15	28 344 (5.3)	285 740	0.17 (0.10 to 0.29)	0.47 (0.28 to 0.82)	0.50 (0.29 to 0.86)
3	37	40 732 (7.6)	426 621	0.38 (0.26 to 0.55)	0.96 (0.65 to 1.42)	1.02 (0.69 to 1.49)
4–6	16	27 389 (5.2)	273 089	0.22 (0.13 to 0.38)	0.66 (0.37 to 1.17)	0.69 (0.39 to 1.22)
≥7	68	24 092 (4.3)	238 940	1.12 (0.85 to 1.49)	1.52 (1.13 to 2.04)	1.51 (1.12 to 2.03)

HR, hazard ratio; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous physical activity.

Sample adults who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019. Restricted to those who did not die within 2 years of the NHIS interview (N=566 771).

^aAdjusted for sex, age, race/ethnicity, education, and marital status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^bAdjusted for sex; age; race/ethnicity; education; marital status; smoking status; alcohol consumption; body mass index; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; and influenza and pneumococcal vaccination status. Aerobic categories are also adjusted for muscle-strengthening categories and vice versa.

^cReported <150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^dReported ≥150 min/wk of moderate-intensity equivalent physical activity and <2 episodes/wk of muscle-strengthening activity.

^eReported ≥2 episodes/wk of muscle-strengthening activity and <150 min/wk of moderate-intensity equivalent physical activity.

^fReported ≥150 min/wk of moderate-intensity equivalent physical activity and ≥2 episodes/wk of muscle-strengthening activity.

Table S6. Hazard Ratios for Influenza and Pneumonia Deaths, by Vigorous-Intensity Aerobic Physical Activity

VPA (min/wk)	Deaths	No. (weighted %)	Person-Years	Unadjusted HR (95% CI)	Adjusted HR ^a (95% CI)	Adjusted HR ^b (95% CI)	Adjusted HR ^c (95% CI)
<10	1316	343 035 (56.6)	3 496 996	1.00 [ref]	1.00 [ref]	1.00 [ref]	1.00 [ref]
10–74	76	68 231 (12.7)	718 826	0.29 (0.22 to 0.38)	0.79 (0.60 to 1.04)	0.87 (0.66 to 1.15)	0.88 (0.67 to 1.17)
75–150	41	62 010 (11.5)	650 634	0.15 (0.11 to 0.22)	0.40 (0.28 to 0.57)	0.44 (0.30 to 0.63)	0.44 (0.31 to 0.64)
>150	83	104 633 (19.2)	1 064 270	0.20 (0.15 to 0.26)	0.48 (0.36 to 0.63)	0.53 (0.40 to 0.69)	0.54 (0.41 to 0.72)

HR, hazard ratio; VPA, vigorous-intensity physical activity.

Sample adults who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019 (N=577 909).

^aAdjusted for sex, age, race/ethnicity, education, marital status, and muscle-strengthening category.

^bAdjusted for sex; age; race/ethnicity; education; marital status; muscle-strengthening category; smoking status; alcohol consumption; body mass index; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; and influenza and pneumococcal vaccination status.

^cAdjusted for sex; age; race/ethnicity; education; marital status; muscle-strengthening category; smoking status; alcohol consumption; body mass index; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; influenza and pneumococcal vaccination status; and light- and moderate-intensity aerobic physical activity (min/week).

Table S7. Hazard Ratios for Influenza and Pneumonia Deaths, by Weekly Episodes of Muscle-Strengthening Activity

MSA (episodes/wk)	Deaths	No. (weighted %)	Person-Years	Unadjusted HR (95% CI)	Adjusted HR ^a (95% CI)	Adjusted HR ^b (95% CI)
0	1355	438 147 (74.4)	4 522 668	1.00 [ref]	1.00 [ref]	1.00 [ref]
1	12	18 236 (3.4)	182 694	0.30 (0.16 to 0.57)	1.03 (0.54 to 1.93)	1.09 (0.58 to 2.05)
2	18	28 519 (5.2)	285 906	0.17 (0.11 to 0.28)	0.51 (0.31 to 0.83)	0.53 (0.33 to 0.87)
3	40	40 996 (7.6)	426 890	0.34 (0.24 to 0.49)	0.93 (0.64 to 1.35)	0.97 (0.67 to 1.41)
4–6	20	27 528 (5.2)	273 241	0.23 (0.14 to 0.38)	0.73 (0.43 to 1.22)	0.76 (0.45 to 1.27)
≥7	71	24 483 (4.3)	239 327	1.01 (0.77 to 1.32)	1.43 (1.07 to 1.90)	1.41 (1.06 to 1.88)

HR, hazard ratio; MSA, muscle-strengthening activity.

Sample adults who participated in the National Health Interview Survey from 1998–2018 and were eligible for linkage to the National Death Index through 2019 (N=577 909).

^aAdjusted for sex, age, race/ethnicity, education, marital status, and aerobic category.

^bAdjusted for sex; age; race/ethnicity; education; marital status; smoking status; alcohol consumption; body mass index; presence of heart disease, stroke, hypertension, diabetes, cancer, chronic obstructive pulmonary disease, and asthma; influenza and pneumococcal vaccination status; and aerobic category.