Dose-Response Association of Aerobic and Muscle-Strengthening Physical Activity with Mortality: A National Cohort Study of 416,420 US Adults

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Table S1. The NHIS Questionnaire on aerobic PA and muscle-strengthening exercise

PA	**Survey Question**
MPA	"How often do you do LIGHT or MODERATE activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate? About how long do you do these light or moderate activities each time?"
VPA	"How often do you do VIGOROUS activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate? About how long do you do these vigorous activities each time?"
MSE	"How often do you do physical activities specifically designed to STRENGTHEN your muscles, such as lifting weights or doing calisthenics? (Include all such activities even if you have mentioned them before)."

Table S2. Akaike information criterion (AIC) and Bayesian information criterion (BIC) of important models using the full cohort. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, smoking status, BMI, chronic conditions, and survey year. Abbreviations: CPH, cox proportional hazard; HHS, U.S. Department of Health and Human Services.

Figure #	Exposure Model	Clusters	AIC	BIC
1	Basic	9	540,806.48	541,303.63
S7	HHS	9	540,861.07	541,297.17
2	Modified HHS	9	540,807.32	541,243.42
n/a	K-Means Clustering	10	540,812.23	541,265.78
S12	K-Means-Informed Clustering	10	540,782.10	541,235.64
3	Cubic Spline Modified HHS	n/a	540,817.65	541,192.70

Diagram 1. Directed acyclic graph of the causal relationship between physical activity and all-cause mortality

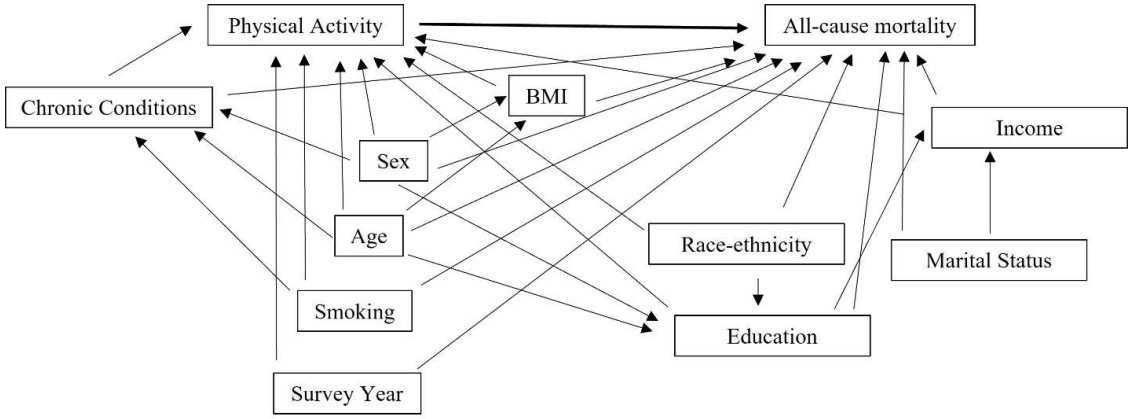

Figure S1. Estimated HRs and 95% CIs for all-cause mortality in the restricted cohort associated with levels of moderate aerobic physical activity (MPA), vigorous aerobic physical activity (VPA), and muscle-strengthening exercise (MSE) relative to less than 30 minutes of MPA, less than 30 minutes of VPA, and 0 times of MSE per week. HRs are estimated using CPH models including indicator variables for different levels of all forms of physical activity. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, BMI, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

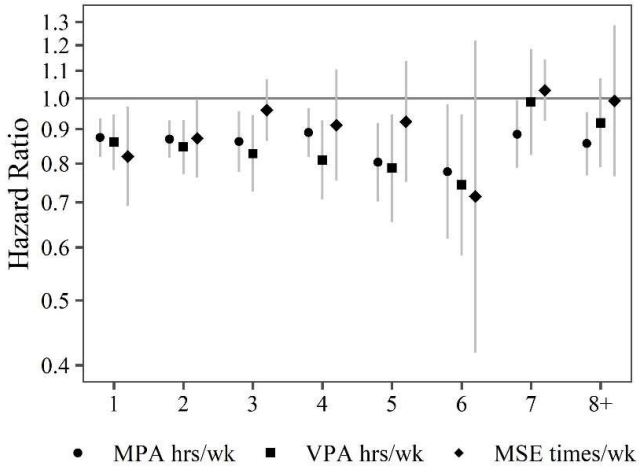

Figure S2. Estimated HRs and 95% CIs for all-cause mortality in the restricted cohort associated with levels of moderate aerobic physical activity (MPA) + vigorous aerobic physical activity (VPA) relative to less than 30 minutes of MPA + VPA. Results are shown stratified by muscle-strengthening activity. Density of individuals in each group of exercise are shown in bars on the lower part of the plot. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, BMI, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

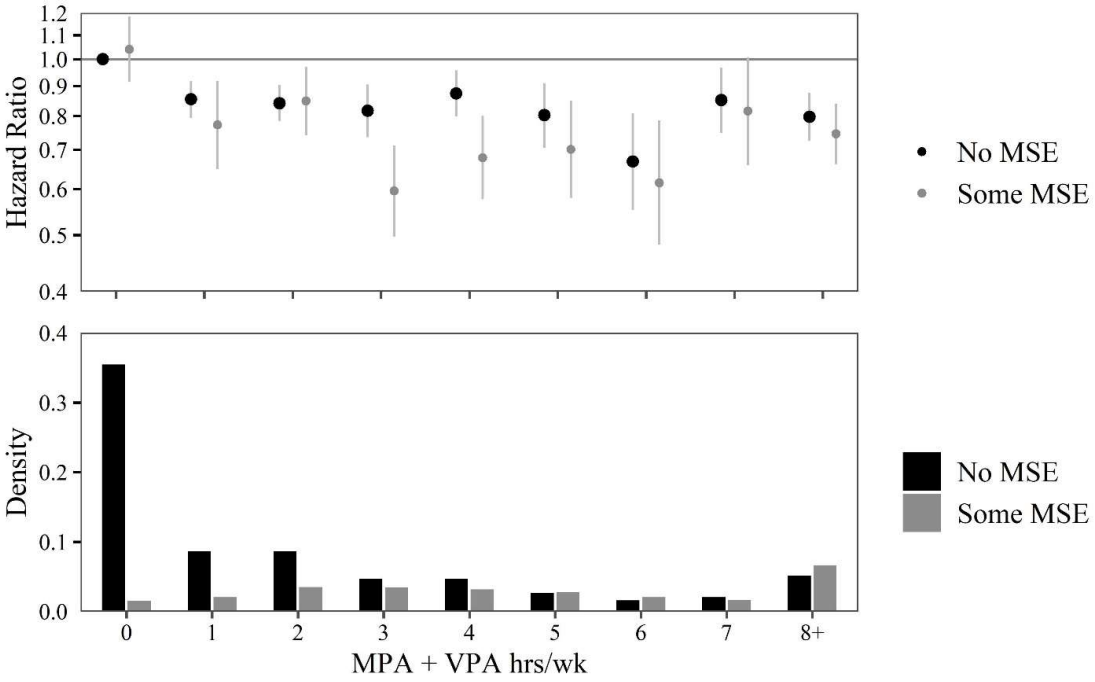

Figure S3. Estimated HRs (solid line) and 95% CIs (dashed lines) for all-cause mortality in the restricted cohort associated with levels of total aerobic physical activity (MPA + VPA) estimated using cubic splines with 3 knots. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, BMI, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; MPA, moderate physical activity; VPA, vigorous physical activity; CPH, cox proportional hazard.

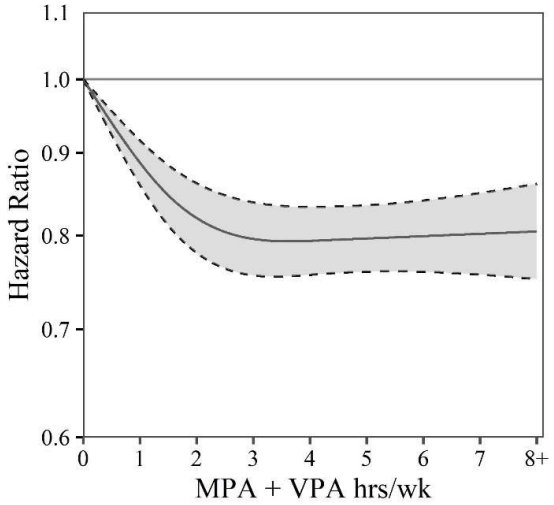

Figure S4. Estimated HRs (solid lines) and 95% CIs (dashed lines) for all-cause mortality in the restricted cohort associated with levels of moderate aerobic physical activity (MPA) + vigorous aerobic physical activity (VPA). MPA + VPA associations are estimated using cubic splines with 3 knots. Results are shown stratified by age (<60 years and 60 + years). CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, BMI, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

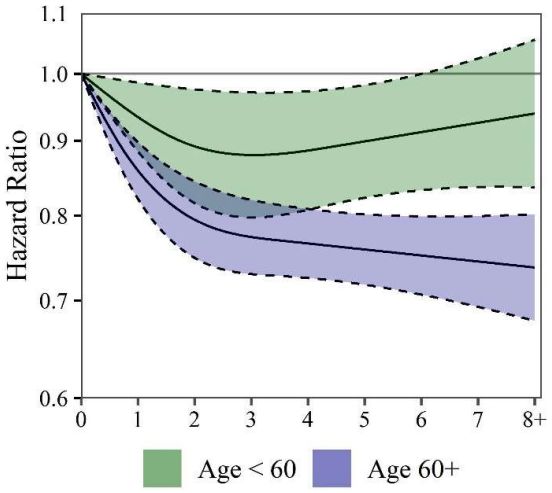

Figure S5. Estimated HRs (solid lines) and 95% CIs (dashed lines) for all-cause mortality in the restricted cohort associated with levels of moderate aerobic physical activity (MPA) + vigorous aerobic physical activity (VPA). MPA + VPA associations are estimated using cubic splines with 3 knots. Results are shown stratified by sex. CPH models allow for combinations of age and race to have their own baseline hazard. CPH models control for income, education, marital status, BMI, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

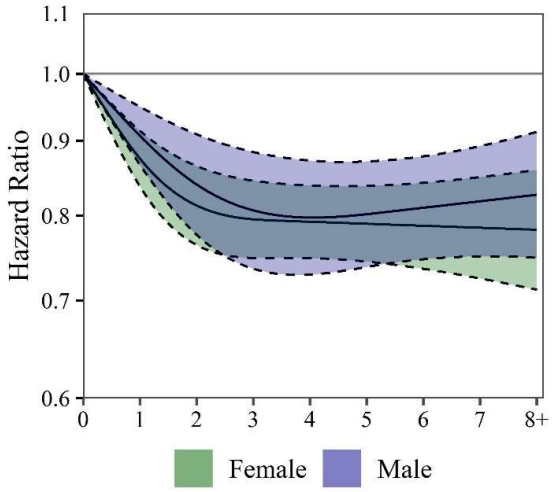

Figure S6. Scatterplot of the NHIS cohort separating by VPA + ½ × MPA. Abbreviations: MPA, moderate physical activity; VPA, vigorous physical activity; NHIS, national health interview survey.

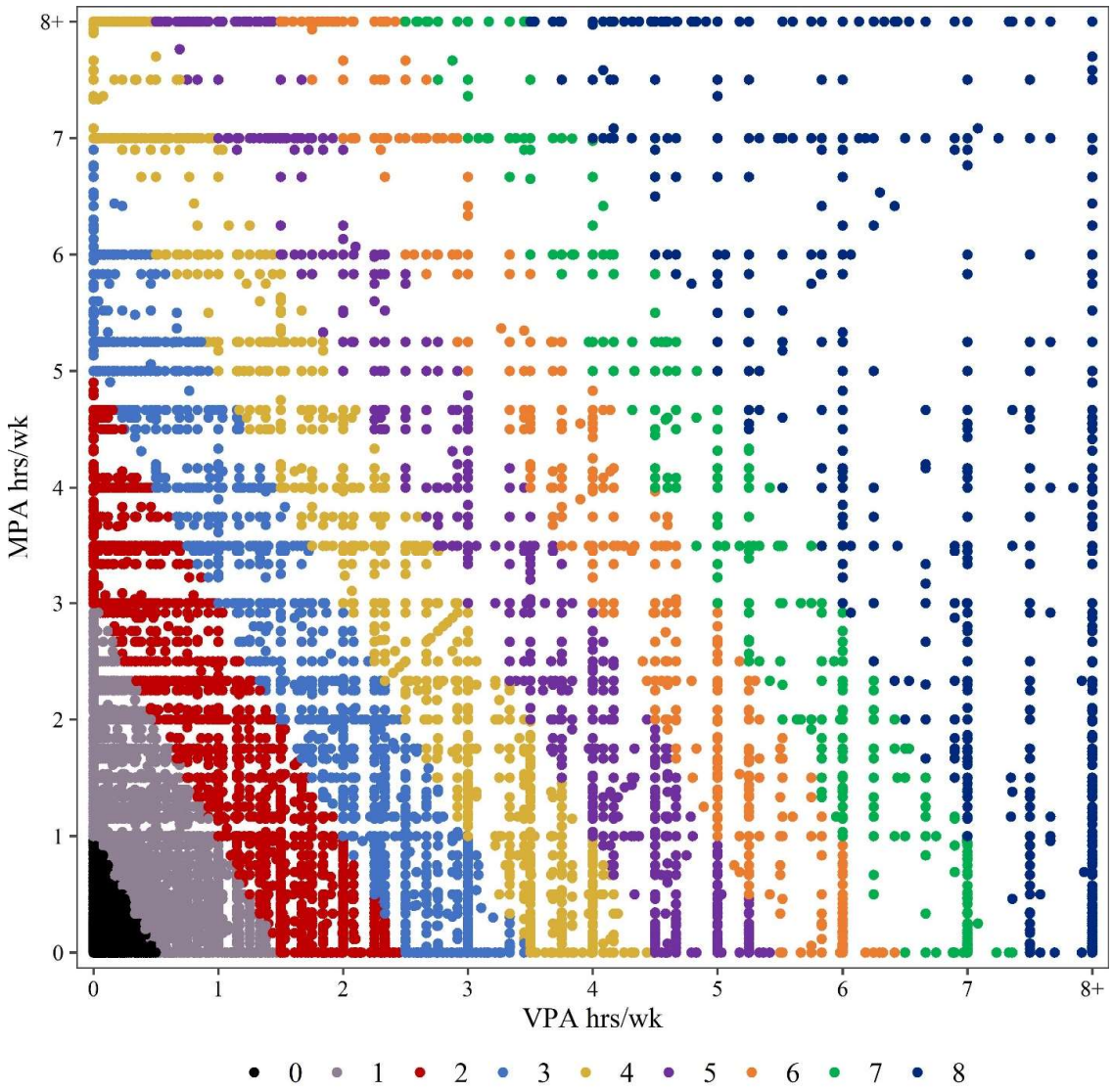

Figure S7. Estimated HRs and 95% CIs for all-cause mortality in the full cohort associated with levels of ½ moderate aerobic physical activity (MPA) + vigorous aerobic physical activity (VPA) relative to less than 30 minutes of ½ × MPA + VPA. Results are shown stratified by muscle-strengthening activity. Density of individuals in each group of exercise are shown in bars on the lower part of the plot. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, smoking status, BMI, chronic conditions, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

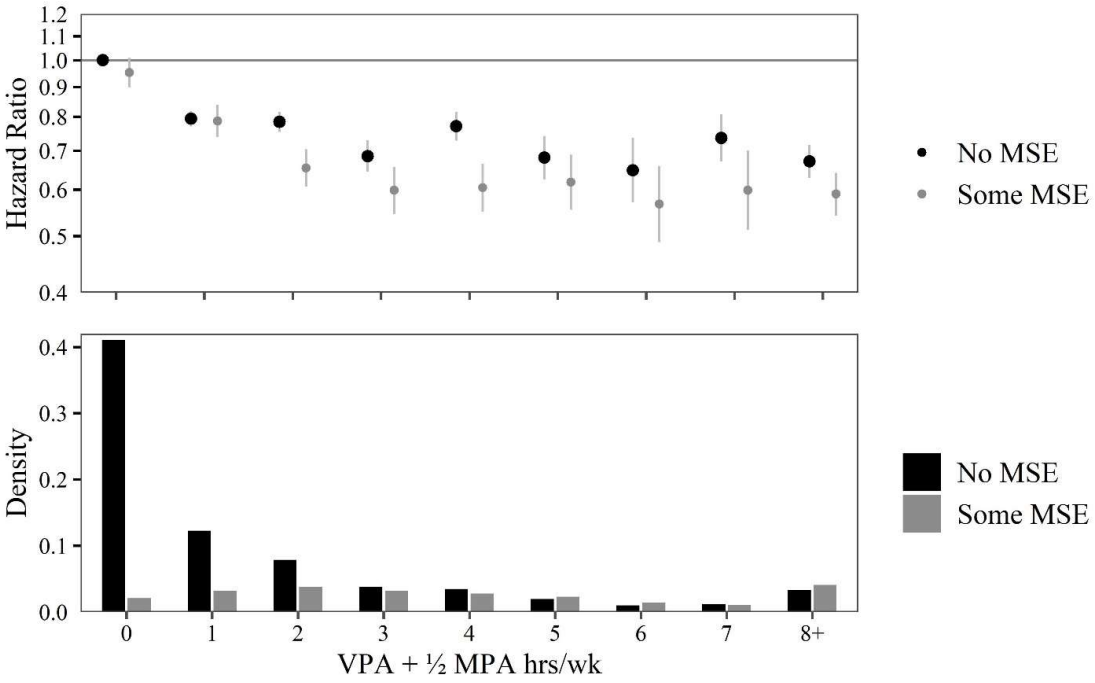

Figure S8. Estimated HRs and 95% CIs for all-cause mortality in the restricted cohort associated with levels of ½ moderate aerobic physical activity (MPA) + vigorous aerobic physical activity (VPA) relative to less than 30 minutes of ½ × MPA + VPA. Results are shown stratified by muscle-strengthening activity. Density of individuals in each group of exercise are shown in bars on the lower part of the plot. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, smoking status, BMI, chronic conditions, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

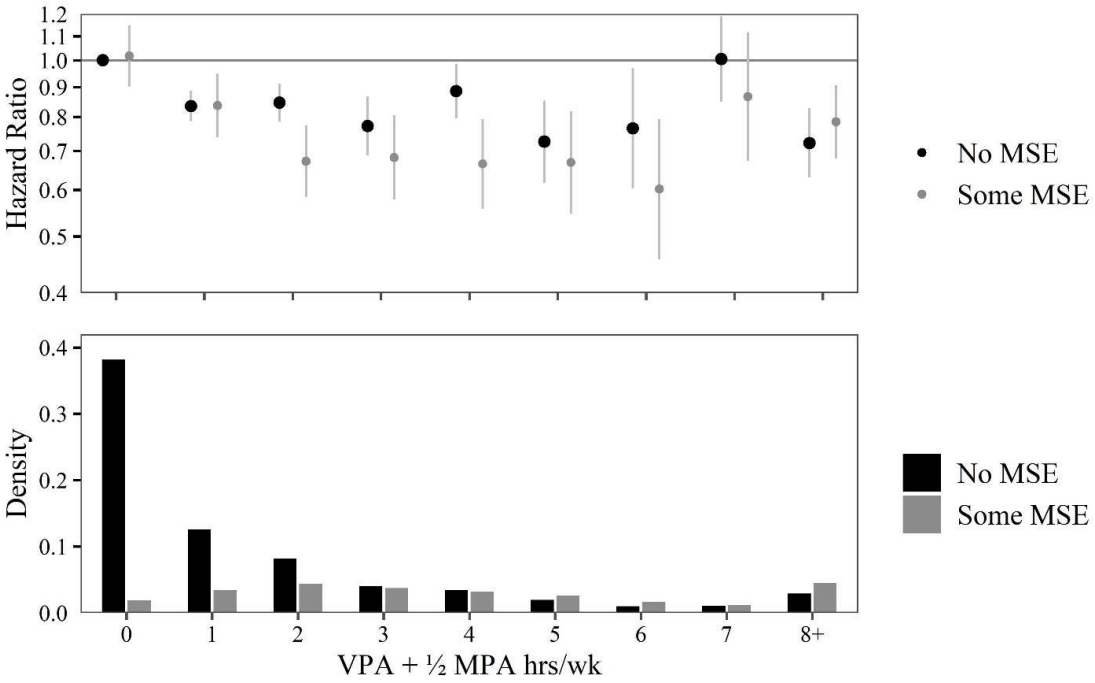

Figure S9. Scatterplot of the NHIS cohort separating by MPA + VPA. Abbreviations: MPA, moderate physical activity; VPA, vigorous physical activity; NHIS, national health interview survey.

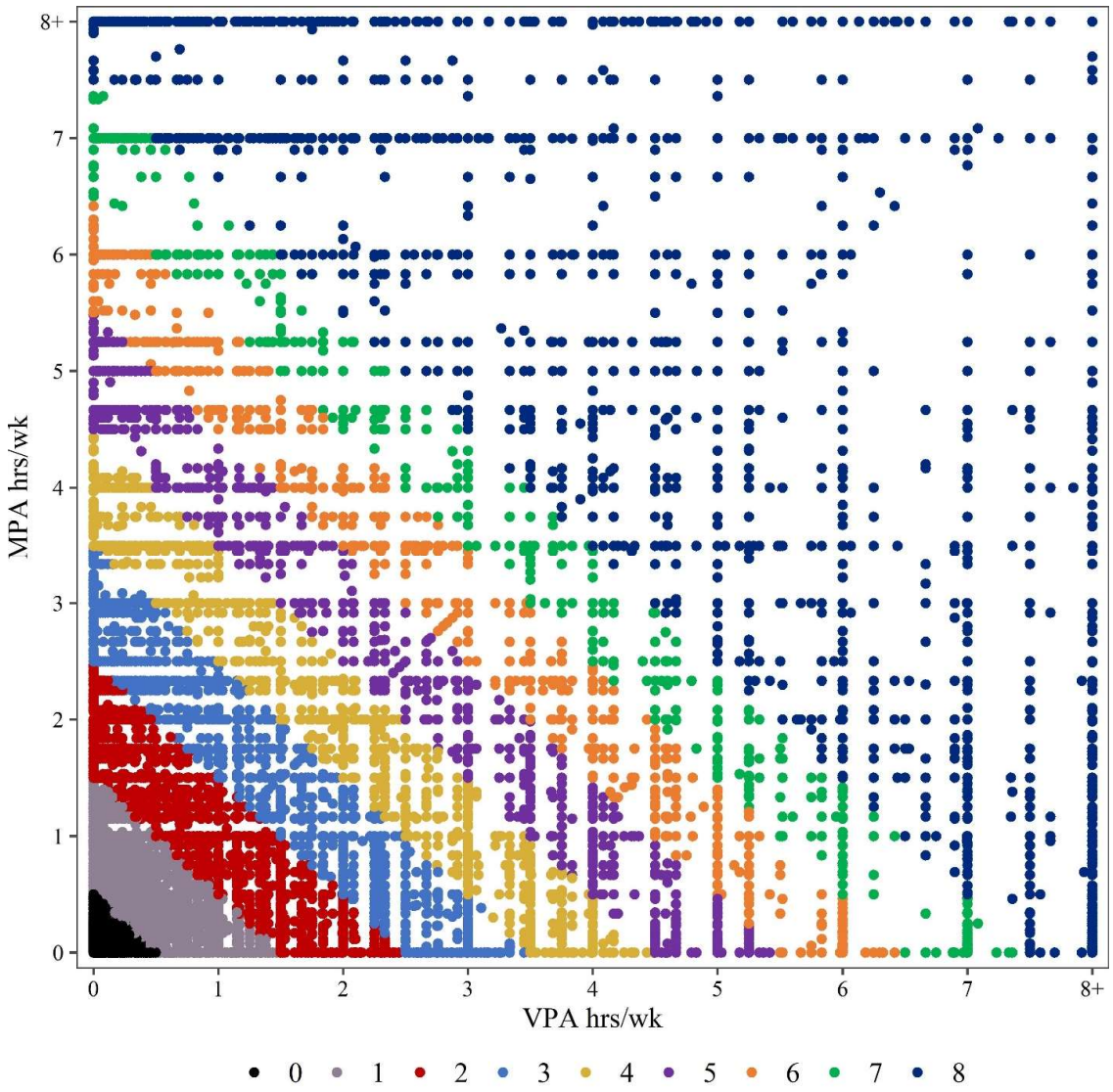

Figure S10. Scatterplot of the NHIS cohort separating by K-means clustering of MPA and VPA. Abbreviations: MPA, moderate physical activity; VPA, vigorous physical activity; NHIS, national health interview survey.

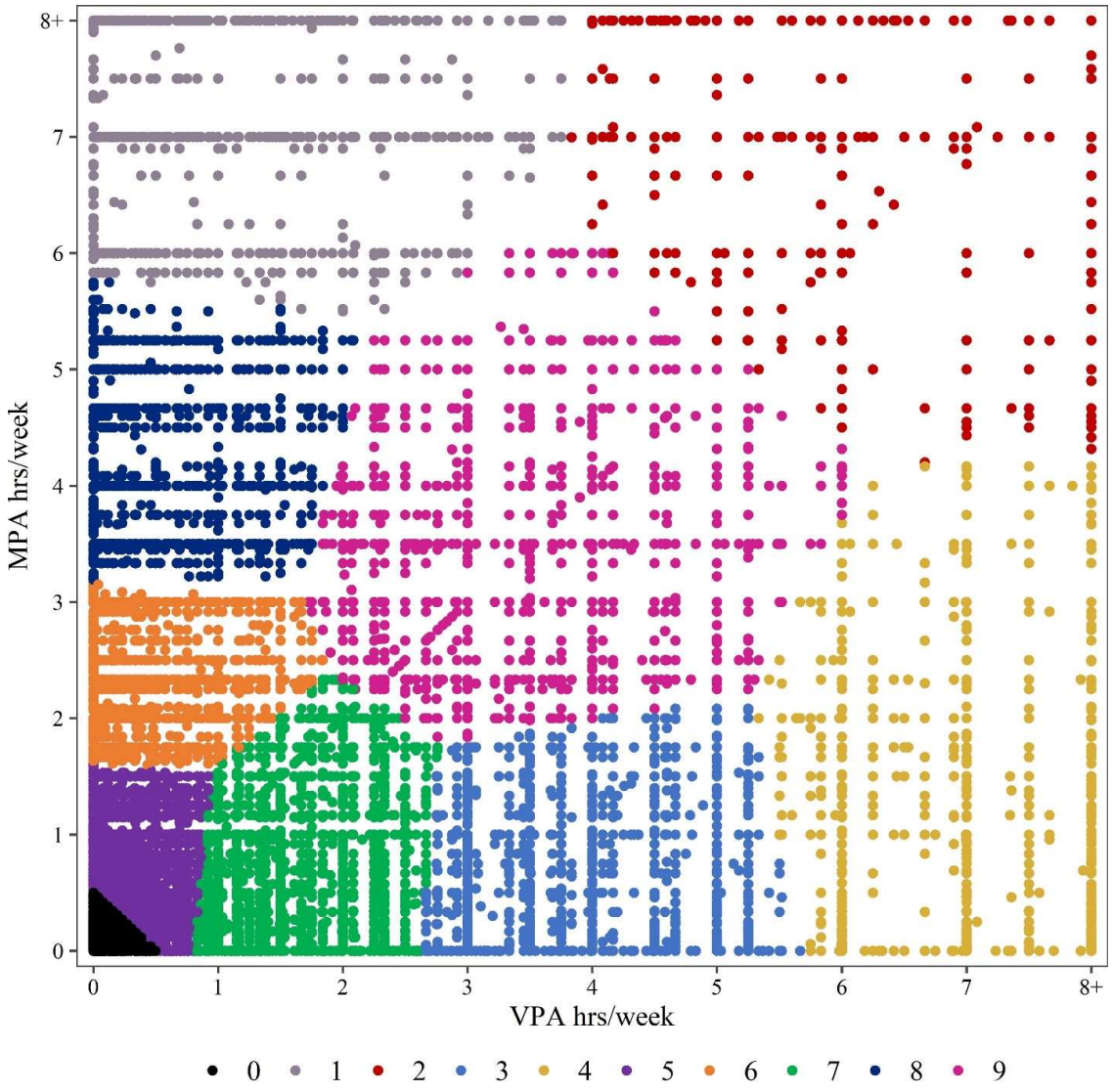

Figure S11. Scatterplot of the NHIS cohort separating by K-means-informed clustering of MPA and VPA. Abbreviations: MPA, moderate physical activity; VPA, vigorous physical activity; NHIS, national health interview survey.

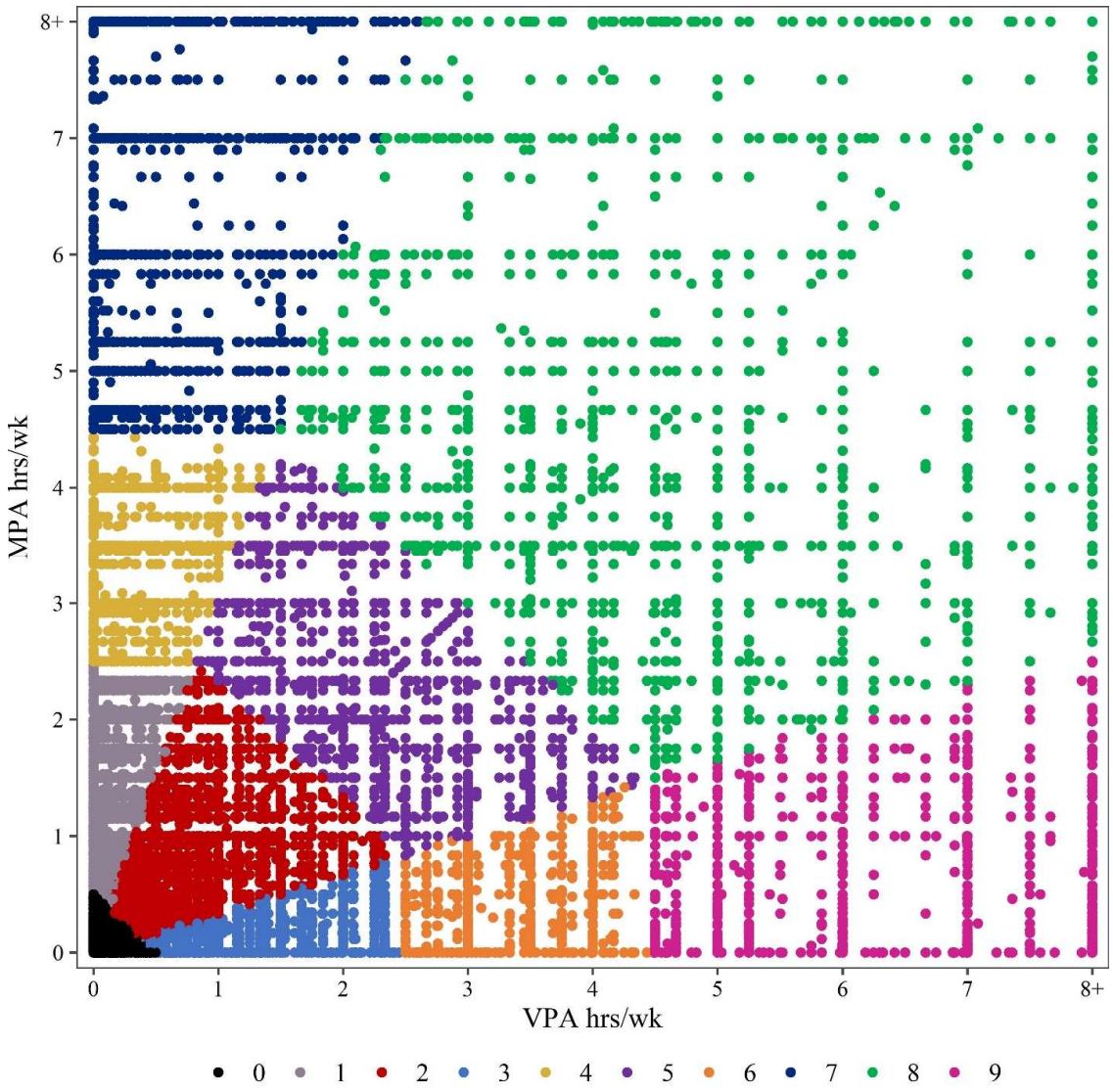

Figure S12. Estimated HRs and 95% CIs for all-cause mortality in the full cohort associated with levels of K-means-informed clusters relative to less than 30 minutes of total aerobic activity. Results are shown stratified by muscle-strengthening activity. Density of individuals in each group of exercise are shown in bars on the lower part of the plot. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, smoking status, BMI, chronic conditions, and survey year. HRs and 95% CIs are plotted on a natural log scale. HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

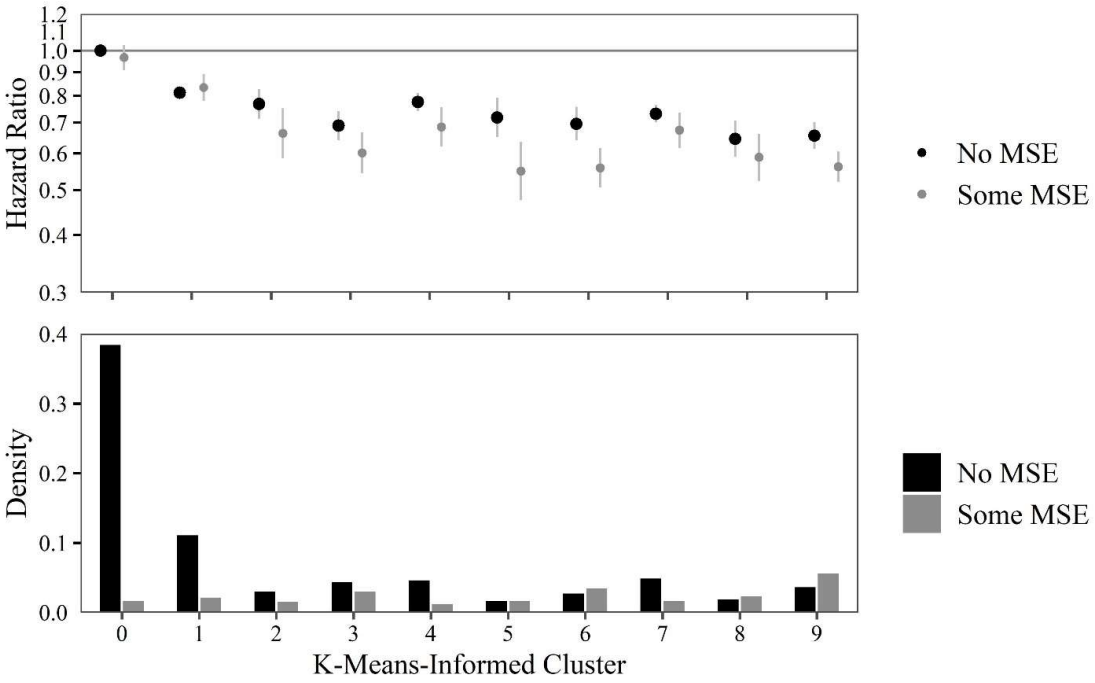

Figure S13. Estimated HRs and 95% CIs for all-cause mortality in the restricted cohort associated with levels of K-means-informed clusters relative to less than 30 minutes of total aerobic activity. Results are shown stratified by muscle-strengthening activity. Density of individuals in each group of exercise are shown in bars on the lower part of the plot. CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, smoking status, BMI, chronic conditions, and survey year. HRs and 95% CIs are plotted on a natural log scale. HR, hazard ratio; CI, confidence interval; CPH, cox proportional hazard.

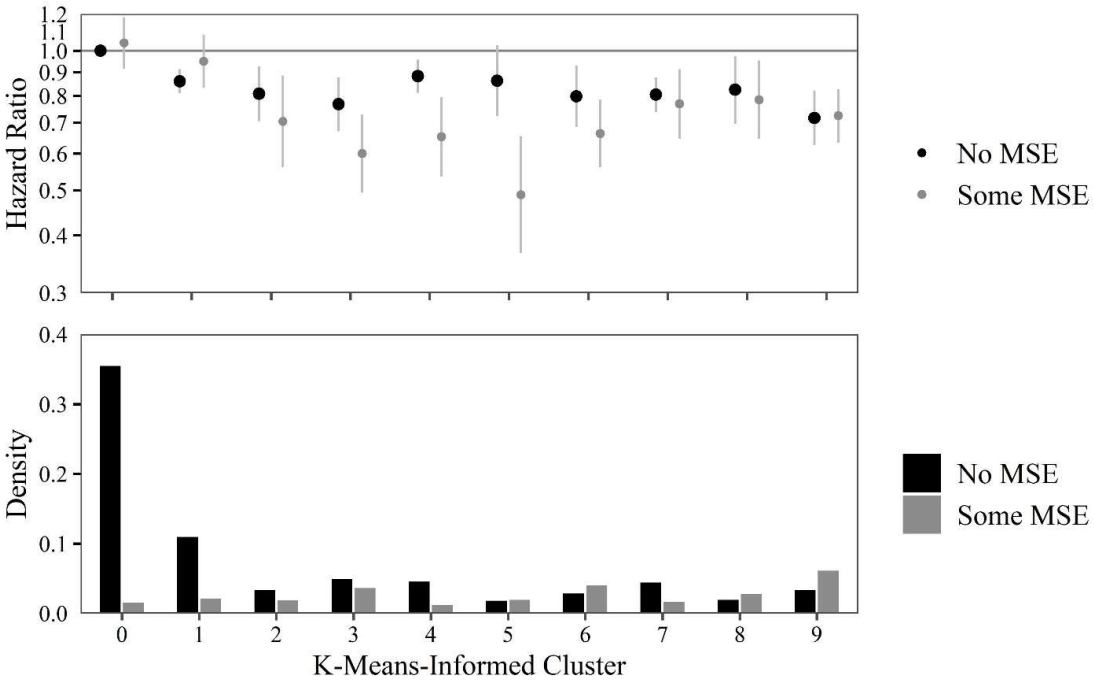

Figure S14. Estimated HRs and 95% CIs for all-cause mortality associated with levels of moderate aerobic physical activity (MPA) + vigorous aerobic physical activity (VPA). MPA + VPA associations are estimated using cubic splines with 3 knots. Results are shown stratified by MSE (no MSE and some MSE). CPH models allow for combinations of age, sex, and race to have their own baseline hazard. CPH models control for income, education, marital status, smoking status, BMI, chronic conditions, and survey year. HRs and 95% CIs are plotted on a natural log scale. Abbreviations: HR, hazard ratio; CI, confidence interval; MSE, muscle-strengthening exercise; CPH, cox proportional hazard.