Similarities in cardiometabolic risk factors among random male-female pairs: A large observational study in Japan

Naoki Nakaya (✉ naoki.nakaya.c2@tohoku.ac.jp)
Tohoku University
Kumi Nakaya
Tohoku University
Naho Tsuchiya
Tohoku University
Akira Narita
Tohoku University
Toshimasa Sone
Fukushima Medical University
Mana Kogure
Tohoku University
Rieko Hatanaka
Tohoku University
Ikumi kanno
Tohoku University
Hirohito Metoki
Tohoku University
Taku Obara
Tohoku University
Mami Ishikuro
Tohoku University
Atsushi Hozawa
Tohoku University
Shinichi Kuriyama
Tohoku University

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Abstract

Background: Spousal similarities exist in several cardiometabolic risk factors and have been noted in previous studies that used public biobank information from two countries. This study aimed to challenge the influence of genetic factors and determine the influence of the environment on cardiometabolic risk factors by using random male-female pairs rather than spouse pairs.

Methods: This cross-sectional study included 5391 spouse pairs from Japan; data were obtained from a large biobank study. For pairings, women of the same age were randomly shuffled to create new male-female pairs of the same age as the original spouse pairs. Similarities in cardiometabolic risk factors between the random male-female pairs were analysed using the Pearson's correlation or age-adjusted logistic regression analyses.

Results: The mean ages of the men and women were 63.2 and 60.4 years, respectively. No significant similarities were noted in cardiometabolic risk factors, including the continuous risk factors (anthropometric traits, blood pressure, glycated haemoglobin level, and lipid traits); lifestyle habits (smoking, drinking, and physical activity); or diseases (hypertension, type 2 diabetes mellitus, and metabolic syndrome) between the random male-female pairs. The age-adjusted correlation coefficients ranged from -0.002 for triglycerides to 0.071 for total cholesterol. The age-adjusted odds ratio (95% confidence interval) for current drinkers was 0.94 (0.81–1.09); ever smokers, 0.99 (0.83–1.18); hypertension, 1.07 (0.93–1.23); and type 2 diabetes mellitus, 1.08 (0.77–1.50).

Conclusion: In this study, no similarities in cardiometabolic risk factors were noted among the random male-female pairs. As spouse pairs may share environmental factors, intervention strategies targeting lifestyle habits and prevent lifestyle-related diseases may be effective.

Background

Several epidemiological studies have investigated the traditional risk factors for cardiovascular diseases. Hypertension, high cholesterol levels, smoking, impaired glucose tolerance, left ventricular hypertrophy, and low levels of high-density lipoprotein-cholesterol (HDL-C) are associated with coronary heart disease [1]. These cardiometabolic risk factors are determined by genetic and environmental factors and their interactions [2–6].

Spousal concordance may be mainly explained by assortative mating and cohabitation effects [7]. Assortative mating is the tendency of people to select mates who bear greater similarities in characteristics such as discernible traits and behaviours (phenotypic assortment) or in social and environmental factors (social homogamy). This causes an initial similarity between spouses. Cohabitation effects could be due to common environmental factors shared by couples or due to “partner interaction effects,” with partners influencing each other’s behaviour [8–10]. If concordance is mainly due to a cohabitation effect, then it should increase with the partnership duration. Assortative mating and/or

cohabitation effects may indicate a higher degree of similarities between a spouse's lifestyle and the associated phenotyping (lifestyle habits, physiological indicators, and diseases).

Observational studies have explored spousal similarities in cardiometabolic risk factors such as blood pressure (BP) [11–17], cholesterol levels [12–14, 16, 17], triglycerides levels [12, 14, 16], abnormal glucose tolerance [11, 12, 14–19], and smoking [13, 18].

In 2021, our international collaborative study assessed data obtained from public biobanks regarding populations in Japan and the Netherlands [20]. This cross-sectional study included 28,265 Dutch Lifelines Cohort Study spouse pairs (recruit from 2006–2013) and 5,391 Japanese Tohoku Medical Megabank Organization (ToMMo) Cohort Study pairs (recruited from 2013–2016). Significant spousal similarities were noted in all the cardiometabolic risk factors (lifestyle habits, anthropometric traits, and diseases) investigated. For example, the odds ratios (ORs) [95% confidence interval (CI)] for spouse pairs were 4.60 (3.52–6.02) for current smoking, 2.83 (2.39–3.35) for current drinking, 2.76 (2.28–3.32) for sufficient physical activity, 1.20 (1.05–1.38) for hypertension, and 1.72 (1.47–2.02) for metabolic syndrome [20].

Environmental factors may play a greater role in spousal similarities than genetic factors. By comparing the results of spouse pairs with those of random male-female pairs, the extent of the influence of the environment on cardiometabolic risk factors can be determined. This study aimed to challenge the influence of genetic factors and determine the influence of the environment on cardiometabolic risk factors by using random male-female pairs rather than spouse pairs. Should the findings of this study support the hypothesis, targeted lifestyle-related interventions are likely to reduce cardiometabolic risk factors among spouses and prevent cardiometabolic diseases. Further, these findings could contribute to important future studies on preventive strategies for cardiometabolic diseases. To investigate the study hypothesis, we analysed data from more than 5,000 male-female pairs using data from a large public biobank study in Japan [21, 22].

Methods

Participants

For this cross-sectional study, data were obtained from the Tohoku Medical Megabank (TMM) Community-based Cohort Study (hereafter referred to as TMM CommCohort Study) that was conducted in Miyagi prefecture, northern Japan (this data was previously published elsewhere) [21, 22]. For the TMM CommCohort Study, participants were recruited for the baseline survey, using two approaches, between May 2013 and March 2016. Participants were recruited at the sites of the annual community health examinations conducted by local governments in Miyagi Prefecture for insured persons aged 40–74 years (Type 1 survey). Additionally, seven Community Support Centre facilities were established in Miyagi Prefecture for voluntary admission-type recruitment and for conducting participant health assessments (Type 2 survey). In the baseline survey, blood and urine samples were collected, as well as self-

administered questionnaires that included information on lifestyle habits, medical histories, and family relationships. A series of physiological tests were also performed.

Individuals aged ≥ 20 years who lived in Miyagi Prefecture were eligible for participation in the study. For the TMM CommCohort Study, self-administered family relationship questionnaires were distributed and collected. All participants were required to answer the following question: “If you are living with family members who are participating in this TMM Project, please specify all their names and birthdays and your relationships with them (your spouse, father, mother, children, grandchildren, children’s spouses, father-in-law, mother-in-law, and others) with their consent.” Based on these responses, if a participant’s spouse was identified as a TMM CommCohort Study participant, then the spouse and the participant were defined as a spouse pair [20]. However, in this study, we created new random male-female using the original spouse pairs. After sorting women of the same age into groups, they were randomly shuffled using the SAS RANUNI function (SAS Institute, Cary, NC, USA), to create new male-female pairs of the same age as the original spouse pairs. Owing to chance, it was possible that a random male-female pair were also a spouse pair.

Data collection and variables

Data on of the following cardiometabolic risk factors were collected: anthropometric traits: height, weight, waist circumference and body mass index (BMI); systolic (SBP) and diastolic BP (DBP); glycated haemoglobin (HbA1c); lipid traits: total cholesterol (TC), triglycerides (TG), HDL-C and low-density lipoprotein-cholesterol (LDL-C); and lifestyle factors. Cardiometabolic diseases such as hypertension, type 2 diabetes mellitus (T2DM), and metabolic syndrome were defined based on the collected data.

Specifically, well-trained staff measured the participants’ height, weight, and waist circumference. BMI was calculated as weight (kg) divided by height (m) squared. BP was measured during municipal health checks (Type 1 survey) and/or at a Community Support Centre (Type 2 survey). For the Type 2 survey, BP was measured twice in the upper right arm using a digital automatic BP monitor (HEM-9000AI; Omron Healthcare Co., Ltd, Kyoto, Japan) after resting in a sitting position for at least 2 min. During the TMM CommCohort Study, non-fasting blood samples were collected using a standard protocol, and HbA1c levels were measured using latex agglutination turbidimetry. TC was measured with cholesterol dehydrogenase using an Ultra Violet-End (UV-End) method. HDL-C and TG were measured using direct and enzymatic methods, respectively. LDL-C was calculated using the Friedewald formula.

Lifestyle factors

Lifestyle habits such as smoking, drinking, and physical activity levels were defined according to the self-reported questionnaires. To assess smoking status, the participants were categorized as current smokers, past smokers, or non-smokers. Ever smokers were defined as those who smoked currently or in the past. Drinking status was assessed by categorizing the participants as current drinkers or non-drinkers. Regarding physical activity, metabolic equivalent (MET) hours/day were calculated by multiplying the MET score for a specific activity by the number of hours spent on that activity per day. For each cohort, we used the 80th percentile of the men’s MET hours/day as a cutoff for dividing physical activity levels

into two categories: (1) sufficiently active (≥ 80th percentile of men's MET hours/day) and (2) inactive (< 80th percentile of men's MET hours/day) [20].

Diseases

Hypertension was defined as an SBP ≥ 140 mmHg, a DBP ≥ 90 mmHg, or the use of antihypertensive medication. Diabetes was defined as an HbA1c ≥ 6.5% or the use of blood glucose-lowering medication. Participants were classified as having metabolic syndrome if they met the first criterion and at least two of the following criteria [23]: 1) a waist circumference ≥ 85 cm in men and ≥ 90 cm in women, 2) hypertension (SBP ≥ 130 mmHg or DBP ≥ 85 mmHg or the use of antihypertensive medication), 3) hyperglycaemia (HbA1c ≥ 6.0% or the use of blood glucose-lowering medication), and 4) high TG/HDL-C levels (triglyceride levels ≥ 1.68 mmol/L [150 mg/dL] or HDL-C < 1.03 mmol/L [40 mg/dL] or the use of lipid-lowering medication).

Educational level

Educational level was determined using the following seven categories: elementary school or junior high school; high school; vocational school; college or technical college; university; graduate school; or other. Educational level was then categorized as follows: low (elementary school or junior high school), medium (high school or vocational school), and high (college or technical college, university, and graduate school). The category "other" was treated as missing data.

Ethical considerations

This study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki and the Ethics Committee at the ToMMo, Tohoku University (Sendai, Japan) reviewed and approved this study protocol (First edition: 2012-4-617, Latest edition: 2021-4-113). All participants provided informed consent prior to participating in the ToMMo Study.

Statistical analyses

For continuous variables, Pearson's correlation coefficient was used to determine correlations between random male-female pairs. To control for the potential confounding effect of age similarity, we also estimated the correlation coefficients for age-adjusted residuals among random male-female pairs. We used separate age-adjusted linear regression models for the men and women and saved the residuals after adjustment. TG values were $\log_{10}$-transformed for normalization prior to calculating the spousal correlations. For those using antihypertensive and/or lipid lowering medication, the SBP, DBP, TC, and LDL values were adjusted to reconstruct the original population ranking of these individuals based on the expected treatment effects. For those using antihypertensive medication, 15 mmHg and 10 mmHg were added to the SBP and DBP values, respectively [20, 24]. For those receiving hyperlipidaemia treatment, the TC and LDL values were divided by 0.8 and 0.7, respectively [20, 25, 26]. When analysing HbA1c levels, those with diabetes were excluded. Outliers (> mean + 5 standard deviation [SD] or < mean − 5 SD) were excluded for all traits.

For categorical variables, logistic regression analyses were performed to determine spousal concordance. To determine the risk in men, ORs and 95% CIs were calculated for current smoking, current drinking, sufficient physical activity, and the presence of diseases in their respective female partners, all of which were considered exposures. To adjust for age in the analyses, two new covariates were calculated: the average age of each spouse and the age difference between random male-female pairs. For random male-female pairs, ORs > 1.0 indicated higher degrees of concordance.

All statistical analyses were performed using the software SAS, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Basic participant characteristics in the TMM CommCohort Study

Of the 76,955 individuals who were invited to participate in the TMM CommCohort Study, 54,952 agreed. After excluding those who withdrew consent, 5,391 spousal pairs were identified using the family relationship questionnaires. From these, 5,391 new random male-female pairs were identified.

Table 1 shows the participant characteristics. Results of the random male-female pairs in this study as well as the spouse pairs (reported in the Atherosclerosis journal 2021) are shown.

Table 1
Characteristics of sociodemographic and cardiometabolic risk factors among spouse pairs and random male-female pairs

	Spouse pairs (Reported in our earlier study) [20]			Random male-female pairs (Exact age-match of spouse pairs)		
	Number of pairs	Husband	Wife	Number of pairs	Male	Female
General characteristics						
Mean age at baseline, years (SD)	5391	63.2 (10.5)	60.4 (10.2)	5391	63.2 (10.5)	60.4 (10.2)
Age group, years (n, %)	5391			5391		
20–39		293 (5.4%)	346 (6.4%)		293 (5.4%)	346 (6.4%)
40–59		931 (17.3%)	1373 (25.5%)		931 (17.3%)	1373 (25.5%)
60–69		2.678 (49.7%)	2995 (55.6%)		2678 (49.7%)	2995 (55.6%)
≥70		1489 (27.6%)	677 (12.6%)		1489 (27.6%)	677 (12.6%)
Education (university or graduate school) (n, %)	5254	1295 (24.6%)	373 (7.1%)	5245	1286 (24.5%)	370 (7.1%)
Education level (n, %)	5254			5245		
Low		643 (12.2%)	443 (8.4%)		643 (12.3%)	440 (8.4%)
Medium		3141 (59.8%)	3884 (73.9%)		3140 (59.9%)	3884 (74.1%)
High		1470 (28.0%)	927 (17.6%)		1462 (27.9%)	921 (17.6%)
Risk factors						
Mean weight, kg (SD)	5390	66.5 (9.6)	54.1 (8.7)	5379	66.4 (9.4)	54.1 (8.6)
Mean height, cm (SD)	5391	166.7 (6.0)	154.3 (5.6)	5391	166.7 (6.0)	154.4 (5.6)

Abbreviations: DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; HDL, high-density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein; MET, metabolic equivalent; SBP, systolic blood pressure; SD, standard deviation

Mean waist circumference, cm (SD)	3183	85.6 (8.2)	81.9 (9.2)	2143	85.6 (8.1)	82.0 (9.0)
Mean body mass index, kg/m^2 (SD)	5198	23.9 (3.0)	22.7 (3.5)	5009	23.9 (3.0)	22.7 (3.5)
Mean SBP, mmHg (SD)	5106	129.7 (16.3)	125.9 (17.7)	4839	134.9 (18.8)	129.6 (20.2)
Mean DBP, mmHg (SD)	5106	78.9 (10.6)	75.2 (10.6)	4835	84.1 (12.9)	78.8 (13.2)
Mean HbA1c, % (SD)	5373	5.6 (0.6)	5.6 (0.5)	4568	5.5 (0.4)	5.5 (0.3)
Mean total cholesterol, mg/dL (SD)	1964	201.5 (33.5)	213.7 (35.9)	841	202.2 (33.6)	211.7 (36.2)
Mean triglycerides, mg/dL [IQR, 25th, 75th]	5384	126.9 [75.0–151.0]	102.3 [64.0–121.0]	5307	127.1 [76.0–155.0]	104.3 [65.0–127.0]
Mean HDL-C, mg/dL (SD)	5384	57.0 (14.5)	66.5 (15.5)	5375	57.0 (14.4)	66.5 (15.5)
Mean LDL-C, mg/dL (SD)	3191	118.9 (29.8)	128.1 (30.4)	2143	125.8 (33.7)	136.9 (33.6)
Lifestyle factors (n, %)						
Current smoker	5313	1104 (20.8%)	248 (4.7%)	5313	1101 (20.7%)	248 (4.7%)
Ever smoker	5313	3170 (59.7%)	918 (17.3%)	5313	3073 (57.8%)	671 (12.6%)
Current drinker	5356	4201 (78.4%)	2187 (40.8%)	5354	4195 (78.4%)	2186 (40.8%)
Sufficient physical activity (≥ 80th percentile of men's MET hours/day)	5342	1074 (20.1%)	549 (10.3%)	5,322	1067 (20.1%)	550 (10.3%)
Prevalence of diseases (n, %)						

Abbreviations: DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; HDL, high-density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein; MET, metabolic equivalent; SBP, systolic blood pressure; SD, standard deviation

Hypertension	4260	2411 (56.6%)	1770 (41.6%)	4037	2271 (56.3%)	1719 (42.6%)
Type 2 diabetes	3469	504 (14.5%)	246 (7.1%)	3355	501 (14.9%)	240 (7.2%)
Metabolic syndrome	3770	1565 (41.5%)	1026 (27.2%)	3697	1501 (40.6%)	1014 (27.4%)

Abbreviations: DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; HDL, high-density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein; MET, metabolic equivalent; SBP, systolic blood pressure; SD, standard deviation

The mean ages of the men and women who participated in this study were 63.2 years and 60.4 years, respectively. Approximately two-third of the participants were ≥ 60 years old. More men indicated that they were current smokers, ever smokers, and current drinkers than women. The prevalence of hypertension, diabetes, and metabolic syndrome was higher among men than among women.

Spousal similarities in cardiometabolic risk factors

Tables 2 and 3 show the correlations and concordances of cardiometabolic risk factors among random male-female pairs and spouse pairs. For the men and women's' ages, the correlation coefficients were 0.934 for both the random male-female pairs and spouse pairs.

Table 2
Correlations of cardiometabolic risk factors among spouse pairs and random male-female pairs

Risk factors	Spouse pairs (Reported in our earlier study) [20]		Random male-female pairs (Exact age-match of spouse pairs)	
	Simple correlation (95% CI)	Age-adjusted correlation (95% CI)	Simple correlation (95% CI)	Age-adjusted correlation (95% CI)
Age at baseline	0.934 (0.930, 0.937)	NA	0.934 (0.930, 0.937)	NA
Weight	0.119 (0.092, 0.145)	0.110 (0.084, 0.137)	0.008 (-0.018, 0.035)	-0.005 (-0.032, 0.002)
Height	0.297 (0.272, 0.321)	0.175 (0.149, 0.201)	0.161 (0.135, 0.187)	0.010 (-0.016, 0.037)
Waist circumference	0.132 (0.098, 0.166)	0.126 (0.092, 0.160)	0.005 (-0.037, 0.047)	0.005 (-0.038, 0.047)
Body mass index	0.134 (0.107, 0.161)	0.136 (0.109, 0.163)	-0.009 (-0.036, 0.019)	-0.007 (-0.035, 0.021)
SBP	0.163 (0.136, 0.190)	0.086 (0.059, 0.113)	0.107 (0.079, 0.135)	0.026 (-0.003, 0.054)
DBP	0.094 (0.067, 0.122)	0.073 (0.046, 0.100)	0.046 (0.018, 0.074)	0.023 (-0.005, 0.051)
HbA1c	0.139 (0.110, 0.167)	0.080 (0.051, 0.109)	0.095 (0.066, 0.124)	0.021 (-0.008, 0.050)
Total cholesterol	0.074 (0.030, 0.118)	0.101 (0.057, 0.145)	0.035 (-0.033, 0.102)	0.071 (0.003, 0.138)
Triglycerides	0.109 (0.083, 0.136)	0.129 (0.102, 0.155)	-0.014 (0.041, 0.013)	0.002 (-0.025, 0.028)
HDL-cholesterol	0.098 (0.071, 0.124)	0.100 (0.073, 0.126)	0.002 (-0.025, 0.029)	0.003 (-0.024, 0.030)
LDL-cholesterol	0.084 (0.050, 0.119)	0.095 (0.060, 0.129)	0.021 (-0.022, 0.063)	0.032 (-0.011, 0.074)

Abbreviations: CI, confidence interval; DBP, diastolic blood pressure; HbA1c, glycated haemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein SBP, systolic blood pressure

Table 3
Concordance of cardiometabolic risk factors among spouse pairs and random male-female pairs

	Spouse pairs (Reported in our earlier study) [20]		**Random male-female pairs (Exact age-match of spouse pairs)**	
	Crude odds ratio (95% CI)	Age-adjusted odds ratio (95% CI)	Crude odds ratio (95% CI)	Age-adjusted odds ratio (95% CI)
Smoking				
Current smokers (vs. non-current smokers)	5.61 (4.33–7.30)***	4.60 (3.52–6.02)***	1.41 (1.05–1.88) *	1.06 (0.78–1.43)
Ever smokers (vs. never smokers)	2.39 (1.94–2.98)***	2.56 (2.06–3.20)***	0.97 (0.82–1.15)	0.99 (0.83–1.18)
Alcohol drinking				
Current drinkers (vs. non-current drinkers)	2.76 (2.30–3.31)***	2.83 (2.39–3.35)***	1.04 (0.88–1.22)	0.94 (0.81–1.09)
Sufficient physical activity (vs. insufficient activity)	2.76 (2.28–3.32)***	2.76 (2.28–3.32)***	1.03 (0.83–1.29)	0.97 (0.77–1.21)
Diseases				
Hypertension (vs. absence)	1.75 (1.54–1.98)***	1.20 (1.05–1.38)**	1.61 (1.41–1.83) **	1.07 (0.93–1.23)
Type 2 diabetes (vs. absence)	1.78 (1.29–2.42)***	1.34 (0.96–1.83)	1.50 (1.07–2.06) *	1.08 (0.77–1.50)
Metabolic syndrome (vs. absence)	2.15 (1.85–2.50)***	1.72 (1.47–2.02)***	1.35 (1.17–1.57) **	1.02 (0.88–1.20)
*P < 0.05, **P < 0.01, ***P < 0.001				
Abbreviations: CI, confidence interval				

Continuous risk factors

For anthropometric traits, the age-adjusted correlation coefficients ranged from − 0.007 (BMI) to 0.071 (TC) among random male-female pairs and from 0.073 (DBP) to 0.175 (height) among spouse pairs. For anthropometric traits, spousal correlations were stronger than those among random male-female pairs. Among spouse pairs, the correlations between body shape, including body weight, abdominal circumference, and BMI were high. In contrast, these correlations were low among random male-female pairs.

Lifestyle factors

Regarding lifestyle habits, the crude OR (95% CI) for the logistic regression analysis was 1.41 (1.05 – 1.88) for current smokers, which demonstrated concordance between random male-female pairs. However, no significant association was noted after adjusting for age. Among spouse pairs, there was a strong spousal concordance for currently smoking (age-adjusted OR = 4.60). Moreover, there was a similarity among spouses for changes in smoking habits, whereby, compared with never-smoking husbands, ever smoking husbands were more likely to have an ever-smoking spouse (OR = 2.56). Further, there were higher degrees of spousal concordance for current drinking and sufficient physical activity (OR = 2.83, and OR = 2.76, respectively).

Diseases

Regarding diseases, the crude ORs (95% CIs) for the logistic regression analyses were 1.61 (1.41 – 1.83) for hypertension, 1.50 (1.07 – 2.06) for T2DM, and 1.35 (1.17 – 1.57) for metabolic syndrome, which demonstrated concordance between random male-female pairs. However, no significant associations were noted after adjusting for age. In contrast, there were strong spousal concordances for hypertension and metabolic syndrome among spouse pairs, with age-adjusted ORs (95% CIs) of 1.20 (1.05–1.38) and 1.72 (1.47 – 2.02), respectively. For diabetes, although the age-adjusted OR was as high as 1.34, no significant association was shown.

Discussion

In our previous study, there were similarities in several cardiometabolic risk factors among spouse pairs [20]. Similarly, many previous studies have shown a high degree of statistically significant similarities or concordances among spouse pairs for cardiometabolic risk factors (anthropometric traits, lifestyle habits, and diseases) [8–19]. This may be owing to environmental factors playing a greater role in spousal similarities than genetic factors. Here, we hypothesized that, when using random male-female pairs rather than spouse pairs, the similarities in cardiometabolic risk factors will be reduced. Using random male-female pairs, we found few significant similarities in cardiometabolic risk factors, including continuous risk factors (anthropometric traits, blood indicators, blood pressure, HbA1c level, and lipid traits), lifestyle habits (smoking, drinking, and physical activity) and diseases (hypertension, T2DM and metabolic syndrome). These findings support our hypothesis that, when using random male-female rather than spouse pairs, the similarities in cardiometabolic risk factors are reduced.

To our knowledge, this is the first study to explore and compare spouse pairs and random male-female pairs. Furthermore, we used a large sample size of over 5,000 pairs to compare and determine concordance for various circulatory and metabolic indicators (blood indicators, lifestyle-related factors, and the prevalence of diseases). Regarding the anthropometric traits, blood indicators, blood pressure, HbA1c level, and lipid traits (continuous variables, Table 2), the age-adjusted correlation coefficients among random male-female pairs were extremely low (-0.007 – 0.071); however, there was a statistically

significant association for TC (correlation coefficient = 0.071). However, this finding should be interpreted with caution because it has low clinical significance owing to the large number of participants.

After quantifying spousal concordance for cardiometabolic risk factors, it was suggested that prevention interventions targeting spouse pairs rather than individuals may be more effective [27]. For example, in a randomized controlled trial focusing on the weight loss effect of exercise training, both overweight spouses achieved significant weight loss [28]. Therefore, focusing on corrective intervention for lifestyle-related factors, which are correctable factors, may improve test values and even prevent diseases. Couples with unfavourable lifestyles may be able to correct their lifestyles and prevent illness by competing with and encouraging each other. Since most couples of a similar age have similar health statuses, it may be possible to prevent cardiometabolic-related diseases by actively encouraging one another to attend health checks (primary prevention) and disease screenings (secondary prevention) [29–31].

This study had some limitations. First, owing to the use of a cross-sectional study design, the timing of new onset hypertension, diabetes, and hyperlipidaemia could not be determined. We only determined the prevalence of cardiometabolic diseases. Thus, future studies should include non-symptomatic participants at baseline and investigate the degree of concordance in new onset cardiometabolic diseases among random male-female pairs during follow-up. Second, the male-female pairs in this study were selected from spouse pairs. An unmarried status has been associated with an increased frequency of unhealthy behaviour (especially in relation to smoking) and psychological issues (especially depression) [32, 33]. Participants in this study who were married likely had higher physical and psychological health levels compared with unmarried individuals. Regardless, in this study, the random male-female pairs were selected from a healthy population and had few significant similarities in cardiometabolic risk factors. We hypothesized that, if unmarried individuals were included, even fewer associations would exist. Third, participants who undergo health check-ups may have a higher-level health consciousness than those who do not [34], which could have caused a volunteer bias in our study. Fourth, for this study, we only targeted the general population in Japan. In our previous study, we performed an analysis using large-scale biobank data from two facilities, one in Japan and the other in the Netherlands. Spouse pairs showed similarities in several cardiometabolic risk factors at both the facilities. As this was a single-centre study, the generalizability of the study findings is limited.

Conclusion

In this cross-sectional study, there were no similarities in cardiometabolic risk factors among random male-female pairs. These findings support our hypothesis that, when using random male-female pairs rather than spouse pairs, the similarities in cardiometabolic risk factors are reduced. As spouse pairs may share environmental factors, intervention strategies that target lifestyle changes and lifestyle-related disease prevention may be effective among spouse pairs.

Abbreviations

HbA1c glycated haemoglobin; BMI body mass index; BP blood pressure; HDL-C high-density lipoprotein-cholesterol; LDL-C low-density lipoprotein-cholesterol; OR odds ratio; CI confidence interval; SBP systolic blood pressure; DBP diastolic blood pressure; TC total cholesterol, TG triglycerides; T2DM type 2 diabetes mellitus

Declarations

Ethics approval and consent to participate

This study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki and the Ethics Committee at the ToMMo, Tohoku University (Sendai, Japan) reviewed and approved this study protocol (First edition: 2012-4-617, Latest edition: 2021-4-113). All participants provided informed consent prior to participating in the ToMMo Study.

Consent for publication

Not applicable

Availability of data and materials

The TMM data sharing policy is publicly available at http://www.megabank.tohoku.ac.jp/english/sample/. Request for use of the TMM biobank data for research purposes should be made by applying to the ToMMo headquarters. All requests are subject to approval by the Sample and Data Access Committee. Details are available upon request at dist@megabank.tohoku.ac.jp.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that may influence the work reported in this paper.

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Authors' contributions

Study design: NN, AH; statistical analysis: NN; manuscript writing: NN, KN, NT, AN, TS, MK, RH, IK, HM, TO, MI, AH, SK; and study manager: SK.

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References

1. Grundy SM, Balady GJ, Criqui MH, Fletcher G, Greenland P, Hiratzka LF, et al. Primary prevention of coronary heart disease: guidance from Framingham: a statement for healthcare professionals from the AHA Task Force on Risk Reduction. American Heart Association. Circulation. 1998;97:1876–87. DOI: 10.1161/01.CIR.97.18.1876.
2. International Consortium for Blood Pressure Genome-Wide Association Studies, Ehret GB, Munroe PB, Rice KM, Bochud M, Johnson AD, *et al.*Genetic variants in novel pathways influence blood pressure and cardiovascular disease risk. Nature. 2011;478:103–9. DOI: 10.1038/nature10405.
3. Nussbaum RL, McInnes RR, Willard HF, Thompson, Thompson. Genetics in Medicine. 8th ed. Amsterdam: Elsevier; 2015.
4. Marenberg ME, Risch N, Berkman LF, Floderus B, de Faire U. Genetic susceptibility to death from coronary heart disease in a study of twins. N Engl J Med. 1994;330:1041–6. DOI: 10.1056/NEJM199404143301503.
5. Bevan S, Traylor M, Adib-Samii P, Malik R, Paul NL, Jackson C, et al. Genetic heritability of ischemic stroke and the contribution of previously reported candidate gene and genomewide associations. Stroke. 2012;43:3161–7. DOI: 10.1161/STROKEAHA.112.665760.
6. Segal JB, Brotman DJ, Necochea AJ, Emadi A, Samal L, Wilson LM, et al. Predictive value of factor V Leiden and prothrombin G20210A in adults with venous thromboembolism and in family members of those with a mutation: a systematic review. JAMA. 2009;301:2472–85. DOI: 10.1001/jama.2009.853.
7. Vandenburg SG. Assortative mating, or who marries whom? Behav Genet. 1972;2:127–57. DOI: 10.1007/BF01065686.
8. Reynolds CA, Barlow T, Pedersen NL. Alcohol, tobacco and caffeine use: spouse similarity processes. Behav Genet. 2006;36:201–15. DOI: 10.1007/s10519-005-9026-7.
9. Grant JD, Heath AC, Bucholz KK, Madden PA, Agrawal A, Statham DJ, et al. Spousal concordance for alcohol dependence: evidence for assortative mating or spousal interaction effects? Alcohol Clin Exp Res. 2007;31:717–28. DOI: 10.1111/j.1530-0277.2007.00356.x.
10. Ask H, Rognmo K, Torvik FA, Røysamb E, Tambs K. Non-random mating and convergence over time for alcohol consumption, smoking, and exercise: the Nord-Trøndelag Health Study. Behav Genet. 2012;42:354–65. DOI: 10.1007/s10519-011-9509-7.
11. Stimpson JP, Peek MK. Concordance of chronic conditions in older Mexican American couples. Prev Chronic Dis. 2005;2:A07.
12. Kim HC, Kang DR, Choi KS, Nam CM, Thomas GN, Suh I. Spousal concordance of metabolic syndrome in 3141 Korean couples: a nationwide survey. Ann Epidemiol. 2006;16:292–8. DOI:

10.1016/j.annepidem.2005.07.052.

13. Pai CW, Godboldo-Brooks A, Edington DW. Spousal concordance for overall health risk status and preventive service compliance. Ann Epidemiol. 2010;20:539–46. DOI: 10.1016/j.annepidem.2010.03.020.
14. Lee MH, Kim HC, Thomas GN, Ahn SV, Hur NW, Choi DP, et al. Familial concordance of metabolic syndrome in Korean population—Korean National Health and Nutrition Examination survey 2005. Diabetes Res Clin Pract. 2011;93:430–36. DOI: 10.1016/j.diabres.2011.06.002.
15. Okuda T, Miyazaki T, Sakuragi S, Moriguchi J, Tachibana H, Ohashi F, et al. Significant but weak spousal concordance of metabolic syndrome components in Japanese couples. Environ Health Prev Med. 2014;19:108–16. DOI: 10.1007/s12199-013-0361-7.
16. Davillas A, Pudney S. Concordance of health states in couples: analysis of self-reported, nurse administered and blood-based biomarker data in the UK Understanding Society panel. J Health Econ. 2017;56:87–102. DOI: 10.1016/j.jhealeco.2017.09.010.
17. Patel SA, Dhillon PK, Kondal D, Jeemon P, Kahol K, Manimunda SP, et al. Chronic disease concordance within Indian households: a cross-sectional study. PLOS Med. 2017;14:e1002395. DOI: 10.1371/journal.pmed.1002395.
18. Jeong S, Cho SI. Concordance in the health behaviors of couples by age: a cross-sectional study. J Prev Med Public Health. 2018;51:6–14. DOI: 10.3961/jpmph.17.137.
19. Wang JY, Liu CS, Lung CH, Yang YT, Lin MH. Investigating spousal concordance of diabetes through statistical analysis and data mining. PLOS ONE. 2017;12:e0183413. DOI: 10.1371/journal.pone.0183413.
20. Nakaya N, Xie T, Scheerder B, Tsuchiya N, Narita A, Nakamura T, et al. Spousal similarities in cardiometabolic risk factors: A cross-sectional comparison between Dutch and Japanese data from two large biobank studies. Atherosclerosis. 2021;334:85–92. DOI: 10.1016/j.atherosclerosis.2021.08.037.
21. Kuriyama S, Yaegashi N, Nagami F, Arai T, Kawaguchi Y, Osumi N, et al. The Tohoku Medical Megabank Project: design and mission. J Epidemiol. 2016;26:493–511. DOI: 10.2188/jea.JE20150268.
22. Hozawa A, Tanno K, Nakaya N, Nakamura T, Tsuchiya N, Hirata T, et al. Study profile of the Tohoku Medical Megabank Community-based cohort study. J Epidemiol. 2021;31:65–76. DOI: 10.2188/jea.JE20190271. [Online; ahead of print].
23. Matsuzawa Y. Definition and the diagnostic standard for metabolic syndrome—committee to Evaluate Diagnostic Standards for Metabolic Syndrome. Nihon Naika Gakkai Zasshi. 2005;94:794–809. (in Japanese). DOI: 10.2169/naika.94.794.
24. Takeuchi F, Akiyama M, Matoba N, Katsuya T, Nakatochi M, Tabara Y, et al. Interethnic analyses of blood pressure loci in populations of East Asian and European descent. Nat Commun. 2018;9:5052. DOI: 10.1038/s41467-018-07345-0.

25. Dewey FE, Murray MF, Overton JD, Habegger L, Leader JB, Fetterolf SN, et al. Distribution and clinical impact of functional variants in 50,726 whole-exome sequences from the DiscovEHR study. Science. 2016;354:aaf6814. DOI: 10.1126/science.aaf6814.
26. Baigent C, Keech A, Kearney PM, Blackwell L, Buck G, Pollicino C, et al. Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90,056 participants in 14 randomised trials of statins. Lancet. 2005;366:1267–78. DOI: 10.1016/S0140-6736(05)67394-1.
27. Gellert P, Ziegelmann JP, Warner LM, Schwarzer R. Physical activity intervention in older adults: does a participating partner make a difference? Eur J Ageing. 2011;8:211. DOI: 10.1007/s10433-011-0193-5.
28. Gorin AA, Lenz EM, Cornelius T, Huedo-Medina T, Wojtanowski AC, Foster GD. Randomized controlled trial examining the ripple effect of a nationally available weight management program on untreated spouses. Obesity (Silver Spring). 2018;26:499–504. DOI: 10.1002/oby.22098.
29. Jackson SE, Steptoe A, Wardle J. The influence of partner's behavior on health behavior change: the English Longitudinal Study of Ageing. JAMA Intern Med. 2015;175:385–92. DOI: 10.1001/jamainternmed.2014.7554.
30. Gram MA, Therkildsen C, Clarke RB, Andersen KK, Mørch LS, Tybjerg AJ. The influence of marital status and partner concordance on participation in colorectal cancer screening. Eur J Public Health. 2021;31:340–6. DOI: 10.1093/eurpub/ckaa206.
31. Arden-Close E, McGrath N. Health behaviour change interventions for couples: A systematic review. Br J Health Psychol. 2017;22:215–37. DOI: 10.1111/bjhp.12227.
32. Saito-Nakaya K, Nakaya N, Fujimori M, Akizuki N, Yoshikawa E, Kobayakawa M, et al. Marital status, social support and survival after curative resection in non-small-cell lung cancer. Cancer Sci. 2006;97:206–13. DOI: 10.1111/j.1349-7006.2006.00159.x.
33. Pomerleau J, Gilmore A, McKee M, Rose R, Haerpfer CW. Determinants of smoking in eight countries of the former Soviet Union: results from the living conditions, lifestyles and health study. Addiction. 2004;99:1577-85. DOI: 10.1111/j.1360-0443.2004.00885.x, PubMed: 15585049.
34. Hozawa A, Kuriyama S, Watanabe I, Kakizaki M, Ohmori-Matsuda K, Sone T, et al. Participation in health check-ups and mortality using propensity score matched cohort analyses. Prev Med. 2010;51:397–402. DOI: 10.1016/j.ypmed.2010.08.017.