The heritability of pescetarianism and vegetarianism

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A B S T R A C T

Genetic factors have a substantial influence on individuals’ food preferences, but less is known about their influence on abstinence from eating meat and fish. Here we looked at the influence genetics may have on pescetarianism (not eating meat but eating fish) and vegetarianism (not eating meat and fish) in a Dutch twin sample (N = 8196). We also examined genetic and environmental influences on abstinence from eating beef, pork, poultry, fish or shellfish separately and explored the reasons individuals gave for not eating these types of meat and fish (e.g., disliking, health concerns or beliefs). Abstinence from eating various meats or (shell)fish varied from 5.3% for beef to 46% for shellfish, and 3.7% did not eat meat (1.9% was pescatarian and 1.8% vegetarian). The prevalence of all abstinences was higher in women than men. Genetic factors accounted for 74% and 77% of variation in pescetarianism and vegetarianism, respectively, with the remaining variance accounted for by non-shared environmental influences. Heritability for abstinence from eating beef, pork, poultry, fish or shellfish ranged from 70 to 80%. Abstention from pork was mostly due to health concerns, abstention from poultry, fish and shellfish because of disliking, and abstention from beef because of beliefs (i.e., religion or convictions). Most pescatarians and vegetarians reported beliefs as one of their reason for abstinence (~75%). Overall, regardless of the fact that different reasons seem to play a role in pescetarianism, vegetarianism and abstinence from eating different meats and fish, genetic factors undergirded all with a similar large magnitude.

1. Introduction

Why do some people love beef whereas others loath it? Recent findings suggest that much of the variance in this and other types of food preferences is accounted for by genetic factors (Çınar, Wesseldijk, Karinen, Jern, & Tybur, 2021; Vink, van Hooijdonk, Willemsen, Feskens, & Boomsma, 2020). For example, genetic factors account for 26–51% of individual differences in preference for meat (Çınar et al., 2021; Teucher et al., 2007; Vink et al., 2020) and 53–60% in the preference for fish and shellfish (Vink et al., 2020). Do genetic factors also account for abstinence from eating meat but not fish (i.e., pescetarianism) or both meat and fish (i.e., vegetarianism)?

To the best of our knowledge, only one study has investigated genetic influences on vegetarianism. In adult Finish twin pairs (N = 7197), genetic factors accounted for the majority of individual differences in vegetarianism (h² = 75%), and the remainder was explained by environmental factors that twins did not share (Çınar et al., 2021). This finding can appear counterintuitive. In Western nations, vegetarianism has increased steadily over the past few decades (e.g., Stewart, Piernas, Cook, and Jebb (2021)). One could argue that not consuming fish or meat is a decision going beyond likes or dislikes and may be related to beliefs (about the environment or religion). Those who reduce (or abstain from) meat consumption report being motivated by desires to become healthier, reduce animal suffering and improve environmental sustainability (North, Klas, Ling, & Kothe, 2021). Beliefs about health and the environmental impact of meat could be socially transmitted, and we might suspect that decisions to abstain from meat are strongly influenced by environmental factors, though we also know that social attitudes are substantially heritable (Martin et al., 1986). Nevertheless, food dislikes or food intolerances also motivate abstention from specific meats, and they might be more heritable than moral ideologies or health concerns (Martin et al., 1986; Polderman et al., 2015). Furthermore, beliefs about one’s own health and the environment could lead individuals to reduce or change meat consumption instead of complete abstinence, for instance by following guidelines to move to a healthier and more sustainable diet by refraining from eating red meat (Springmann et al., 2018). It is therefore valuable to compare genetic influences on, and compare the reasons given for, abstinence from eating specific meats and fish.

In this short communication, we aim to test whether the high

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heritability of vegetarianism observed in Finland (Çınar et al., 2021) replicates in the Netherlands. We further extend these findings by investigating the degree of genetic and environmental influences on (1) not eating meat but eating fish (i.e., being pescatarian), (2) not eating meat and not eating fish (i.e., being vegetarian), (3) not eating meat (both pescatarians and vegetarians) and (4) abstinance from eating beef, pork, poultry, fish or shellfish separately. In addition, we explore the reasons individuals give for not eating these types of food (e.g., dislike, food intolerances, beliefs), and we compare whether different main reasons for abstention from individual meats or fish correspond with different heritability estimates.

2. Methods

2.1. Participants

Participants were members of the Netherlands Twin Register (NTR) who completed the 11th wave of data collection in 2015 (Ligthart et al., 2019; Vink et al., 2020). To estimate the heritability of pescitarianism and vegetarianism, we analyzed data of twins as well as the first and second born of triplets (N = 60) with information on zygosity (total N = 8196). The zygosity of the same-sex twins was determined by DNA markers or responses to standard survey questions about physical similarities between the twins (Ligthart et al., 2019). In total, 1098 monozygotic male (MZM; 352 complete pairs), 685 dizygotic male (DZM; 187 complete pairs), 2989 mononyzgotic female (MZF; 1138 complete pairs), 1500 dizygotic female (DZF; 466 complete pairs), and 1833 opposite-sex (DOS; 464 complete pairs) twins were included in this study. The mean age of the participants was 35.25 years old (SD 15.26). Approximately 26% of those we contacted participated in the study (Ligthart et al., 2019). Informed consent was obtained from all participants. All research methods were performed in accordance with relevant guidelines and regulations.

2.2. Measures

Participants were asked ‘Do you eat this food or not?’ for the following food types: fish, shellfish, red meat (beef), pork, poultry, gluten, dairy, eggs, sweets, soy, nuts and alcohol. If they answered ‘no’, the follow up question was “If not, for what reason(s)”. The possible answer options were: allergic, intolerant (e.g., impaired digestion of the food), sensitive (e.g. feel discomfort following eating), illness (e.g. inflammatory bowel disease), better for long-term health, better for weight loss/maintenance, beliefs (e.g. religion, veganism), dislike or other reason. Participants were allowed to give more than one reason. Participants who indicated that they did not eat beef, pork and poultry, but did eat fish or shellfish, were classified as pescatarians; all other participants were classified as non-pescatarians (including vegetarians). Similarly, participants who were pescatarians but also abstained from fish and shellfish were classified as vegetarians, and all others were classified as non-vegetarians (including pescatarians). We additionally analyzed everyone who did not eat meat (beef, pork and poultry, therefore including both pescatarians and vegetarians). We further analyzed the dichotomous variables (yes/no) for each individual meat and fish type (beef, pork, poultry, fish or shellfish), resulting in a total of eight outcomes analyzed.

Participants also provided information on demographic characteristics such as gender, age, height, weight, and educational level. BMI was calculated by dividing weight in kilograms by height in meters squared. Participants were categorized as overweight (BMI ≥ 25) versus non-overweight (BMI < 25). The eight levels of educational were recoded into (0) primary school only, (1) lower vocational school and lower secondary school, (2) intermediate vocational school and intermediate or higher secondary school and (3) higher vocational school and university.

2.3. Statistical analyses

We first calculated demographic mean scores (or, for categorical variables, prevalence) for pescatarians, vegetarians, and abstainers from each individual meat and fish type. We tested for significant differences in demographics (gender, age, education, mean health, BMI and overweight) using logistic regression analyses, with vegetarianism, pescatarianism, not eating meat, and abstinance from individual foods as the outcome variables and the demographic characteristic as the predictor. We chose an alpha level of 0.01 due to conducting multiple tests. We corrected for the relatedness of the twins using the robust standard error estimator for clustered observations in STATA (Rogers, 1994; Williams, 2000). For the group who abstained, we obtained frequencies for the different reasons they gave for abstaining.

Next, we performed structural equation modeling in OpenMx in R (Boker et al., 2011). For each of the eight outcomes (pescatarianism, vegetarianism, not eating meat, no beef, no pork, no poultry, no fish, no shellfish), we estimated zygosity-specific tetrachoric correlations. These correlations reflect the resemblance between twins on the underlying liability scale of a dichotomous trait, where a threshold (z-score) divides the continuous liability into ‘cases’ and ‘controls’ (Derks, Dolan, & Boomsma, 2004; Falconer, 1996). We allowed for sex-specific thresholds to account for mean differences between males and females.

We then proceeded with a genetic structural equation model, in which variance in the liability scale is partitioned into additive genetic (A), non-additive genetic (D), common environmental (C), and non-shared environmental (E) components. Because monozygotic (MZ) twins share ~100% of their genes, while dizygotic (DZ) twins share on average 50% of their segregating genes, we infer that genetic factors underlie individual differences in the outcome when the within twin-pair correlations are higher in MZ twins than in DZ twins (Boomsma, Busjahn, & Peltonen, 2002). DZ correlations more than half as large as MZ correlations imply that common environmental influences also contribute to individual differences in the outcome. DZ correlations less than half as large as MZ correlations imply that non-additive genetic influences also contribute to those individual differences. The effects of C and D factors cannot be estimated simultaneously in the classical twin design, and either an ACE or ADE model is chosen based on a visual inspection of the MZ and DZ correlations. Variance unexplained by A and C or D is attributed to E, which also includes measurement error. To test for significant C or D components, we fitted additional AE models after fitting the ACE or ADE model. Significance testing was by likelihood-ratio tests, where twice the difference between the negative log-likelihoods (-2LLs) of the two models is distributed as a chi-square (p), and if the constraints did not significantly diminish model fit (p > 0.01; 1 degree of freedom), the more parsimonious AE model was chosen. In total, we fitted eight models, all with one threshold for men and one for women.

3. Results

3.1. Descriptives

The proportion of individuals abstaining from different types of meat or fish varied greatly, from only 5.3% abstaining from beef to nearly 46% abstaining from shellfish (see Table 1). Only 1.9% of the sample was pescatarian, 1.8% was vegetarian, and 3.7% of the sample did not eat meat. Table 1 shows the demographic characteristics of the study sample, split for abstainers and consumers of the different food types, pescatarians, vegetarians and no meat eaters. The majority of the sample was female (69.1%) and had a relatively high education (59.3%). The mean BMI was 23.3 (SD = 3.6), and 25.1% of the sample was overweight (BMI > 25). Women were more likely than men to abstain from each individual type of food except fish. For the majority of foods, individuals who abstained were more highly educated, with the exception of abstainers from poultry and shellfish. In addition, abstainers from fish, shellfish and vegetarians were younger, but abstainers from pork were...
on average older than the consumers. The average BMI was slightly lower in abstainers than consumers from the different types of meats and in pescatarians and vegetarians. The percentage of overweight individuals followed the same pattern, although the difference was not significant for abstaining or not from poultry and for vegetarians and non-vegetarians.

3.2. Reasons for abstinence from eating meat and/or fish

The reasons individuals gave for abstaining varied greatly depending on the type of meat or fish (see Table 2). Only for beef did the majority (62%) of the abstainers reported ‘beliefs’ (e.g., religious or veganism) as a reason. People mostly abstained from pork for health concerns (36.1%) and from poultry (44.5%), fish (74.4%) and shellfish (73.2%) due to dislike. The majority of pescatarians and vegetarians (69.4–76.6%) reported beliefs as their reason for abstaining from each individual type of meat and fish.

3.3. Genetic and environmental influences on the abstinence from eating meat and/or fish

Resemblance in abstinence was much higher within MZ twin pairs than DZ twin pairs for each individual meat and fish types, as it was for pescetarianism and vegetarianism. This pattern indicates the influence of genetic factors (see MZ and DZ tetrachoric correlations in Table 3). Genetic modelling, which included sex-specific thresholds to account for the sex differences in abstention, showed large genetic influences on abstinence from eating each food type, ranging from 68% for poultry and pork to 79% for beef (see Table 3). For abstinence from eating pork, the influence of common environmental factors (28%, CI 0–53) was just non-significant ($\chi^2 = 3.94, p = .05$). For abstinence from eating all other types of meat and fish, we also found no significant influence of either the common environment or non-additive genetic factors (all p > .39). Pescetarianism was 74% heritable, vegetarianism was 77% heritable and not eating meat was 80% heritable, with the remaining variance accounted for by non-shared environmental influences.

Table 2

<table>
<thead>
<tr>
<th>Number of abstainers</th>
<th>Reasons for abstinence from</th>
<th>Allergic</th>
<th>Intolerant</th>
<th>Sensitive</th>
<th>Illness</th>
<th>Better for health</th>
<th>Better for weight</th>
<th>Beliefs (e.g., religion, veganism)</th>
<th>Dislike</th>
<th>Other reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef 427 (5.3%)</td>
<td></td>
<td>1 (0.2%)</td>
<td>12 (2.9%)</td>
<td>11 (2.7%)</td>
<td>4 (1.0%)</td>
<td>61 (14.8%)</td>
<td>19 (4.6%)</td>
<td>255 (62.0%)</td>
<td>105 (25.5%)</td>
<td>46 (11.2%)</td>
</tr>
<tr>
<td>Pork 1,141 (14.2%)</td>
<td></td>
<td>30 (2.6%)</td>
<td>42 (3.7%)</td>
<td>95 (8.3%)</td>
<td>18 (1.6%)</td>
<td>412 (36.1%)</td>
<td>89 (7.9%)</td>
<td>302 (26.5%)</td>
<td>392 (34.4%)</td>
<td>112 (9.8%)</td>
</tr>
<tr>
<td>Poultry 786 (9.8%)</td>
<td></td>
<td>2 (0.3%)</td>
<td>4 (0.5%)</td>
<td>11 (1.4%)</td>
<td>1 (0.1%)</td>
<td>32 (4.5%)</td>
<td>8 (1.0%)</td>
<td>245 (31.2%)</td>
<td>349 (44.5%)</td>
<td>180 (22.9%)</td>
</tr>
<tr>
<td>Fish 850 (10.6%)</td>
<td></td>
<td>17 (2.0%)</td>
<td>6 (0.7%)</td>
<td>27 (3.2%)</td>
<td>2 (0.2%)</td>
<td>9 (1.1%)</td>
<td>3 (0.4%)</td>
<td>134 (15.8%)</td>
<td>632 (74.4%)</td>
<td>96 (11.3%)</td>
</tr>
<tr>
<td>Shellfish 3,672 (45.8%)</td>
<td></td>
<td>84 (2.3%)</td>
<td>19 (0.5%)</td>
<td>108 (2.9%)</td>
<td>8 (0.2%)</td>
<td>24 (0.7%)</td>
<td>7 (0.2%)</td>
<td>178 (4.9%)</td>
<td>2,686 (73.2%)</td>
<td>694 (18.9%)</td>
</tr>
</tbody>
</table>

For pescetarians and not eating meat N (%) 3 times: N and percentage of participants who marked this reason for all 3 types of meat. For vegetarians: N (%) 5 times: N and percentage of participants who marked this reason for all 5 types of meat and (shell)fish.
4. Discussion

In a large Dutch twin sample, we found that genetic variance accounted for 74% and 77% of whether people were pescatarian or vegetarian, respectively. The remaining variance was accounted for by non-shared environmental influences. Hence, we detected no effect of the common environment, which should include social transmission from parents and other forms of environmental exposures shared by twins. These results are in line with findings from the recent Finnish study that found vegetarianism/veganism to be 76% heritable (Ginar et al., 2021). We replicated the heritability estimate in a sample of a similar age (Finnish sample M = 29.51 years, SD = 7.84, Dutch sample M = 35.25 years, SD = 15.26), though with a much lower prevalence of vegetarianism. This is, however, roughly in line with country-specific prevalence for vegetarianism (approximately 4–5% in the Netherlands and 11% in Finland) (Motroen, 2020; van Rossum, Buurma-Rethans, Dinnissen, Beukers, Brants, & Ocké, 2020). Furthermore, we found the degree of genetic influences on abstaining from beef, pork, poultry, fish and shellfish to all be roughly around 70–80%. Notably, common environment factors were strongest for abstention from pork (28%), though the influence was non-significant with an alpha of 0.01 (corrected for multiple testing). In a previous study, the heritability of food preference was explored in the same sample (Vink et al., 2020). The broad sense heritability for liking of meat and fish, measured on a continuous scale, varied between 41% and 60%. This suggests that genetic factors play a larger role in abstinence from eating meat and fish than in the liking of these foods.

Pork was the only type of meat that individuals in our sample abstained from mostly because of health concerns. Beliefs, which was often selected as a reason not to eat particular types of meat (especially for beef and not eating meat), could reflect religion or conviction (in the survey the example given was veganism). We recommend future studies to differentiate the reason ‘beliefs’ and ask in more depth about the logical mechanisms (e.g., genes related to taste, as has been found for coriander abstinence (Eriksson et al., 2012), versus genes related to other reasons). It could be that concerns about animal welfare and environmental sustainability were not among the response options, these ‘other reasons’ could have reflected such concerns. Additionally, some people might not eat certain types of meat or fish because they are too expensive (like shellfish), although the prevalence of being pescatarian and vegetarian was higher among higher educated participants (with probably higher incomes) than moderate or lower educated participants. Overall, regardless of the fact that different reasons seem to motivate abstention from beef, poultry, fish or shellfish, genetic factors undergirded abststinence from eating all types of meat and fish with a similar magnitude (around 70–80%).

This study has limitations. We made use of self-reports. Whereas participants in the earlier Finnish sample answered yes or no to being vegetarian or vegan (Ginar et al., 2021), participants in the current study were designated as pescatarian or vegetarian based on reporting abstaining from eating specific types of meat and fish. It is possible that, in the Finnish sample, being vegetarian was interpreted as abstaining from eating meat, but not fish, or as abstaining only from certain types of meat. Conversely, some participants in the current study could abstain from beef, pork or poultry, but eat a different type of meat. Further, standard assumptions of classical twin modeling apply here (Verweij, Mosing, Zietsch, & Medland, 2012). Inferences are limited to the population which was approached for the study. The factors underlying vegetarianism in other populations might be different, especially for populations from different cultures, with different religions and/or a higher prevalence of vegetarianism. Lastly, we were initially also interested in investigating environmental and genetic influences on abstaining from all types of meats, fish and dairy (i.e., being vegan). However, our sample included only 20 vegans. Similarly, the majority of pescatorians and vegetarians were female and the data therefore did not allow to investigate sex differences in the genetic architecture. Larger sample sizes are needed to examine genetic influences on veganism, differences between males and females in the heritability of food abstination, and genetic correlations between abstecake from different types of food. Genetic correlations (with either twin studies or molecular genetic approaches) between vegetarianism and other variables (e.g., education or personality traits) could shed light on the mechanisms underlying dietary choices. We would expect that abstaining for reasons like beliefs with respect to sustainability and animal welfare are more related to genetic factors for personality, while abstaining for reasons like dislike or allergy are more related to genetic factors for biological processes (for example, genes that code for taste receptors). For this second scenario, we expect that molecular genetic studies will identify genetic variants that shed more light on the underlying biological mechanisms (e.g., genes related to taste, as has been found for coriander abstinence (Eriksson et al., 2012), versus genes related to personality).
To conclude, we confirmed that genetic factors play a large role in individual’s choice to be pescatarian, vegetarian or to not eat meat (74–80%) in a Dutch population. Genetic influences on abstaining from beef, pork, poultry, fish and shellfish ranged from 70 to 80%, regardless of the fact that different reasons seem to motivate abstinence from these different types of food. Future research should further investigate genetic correlations and genetic influences on associations between vegetarianism and other psychological traits.

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Declaration of Competing Interest

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

Data availability

The authors do not have permission to share data.

References


