1	Factors influencing the intention of young adults to adopt genotype-based personalised
2	advice on diet and physical activity according to perceived weight status.
3	
4	Alexandra King ¹ , Mark Glaister ¹ , Kate Lawrence ¹ , Leta Pilic ¹ , Yiannis Mavrommatis ¹
5	¹ Faculty of Sport, Technology and Health Sciences, St Mary's University, Twickenham, UK
6	
7	Corresponding author: Alexandra King, Faculty of Sport, Technology and Health Sciences,
8	St Mary's University, Twickenham, TW1 4SX, UK. alexandra.king@stmarys.ac.uk. 0208
9	2404112.
10	
11	Short title: Genotype-based personalised advice
12	
13	Abbreviations:
14	BMI: body mass index
15	HLC: health locus of control
16	NCD: non-communicable diseases
17	PBC: perceived behavioural control
18	T2D: type 2 diabetes

19 TPB: Theory of Planned Behaviour

1 Factors influencing the intention of young adults to adopt genotype-based

2 personalised advice on diet and physical activity according to perceived

- 3 weight status.
- 4

5 Abstract:

6 Genotype-based dietary and physical activity advice can be delivered to young adults before unhealthy lifestyle behaviours or metabolic and physiological conditions have developed. The 7 aim of the present study was to investigate the factors that influence the intention to adopt 8 9 genotype-based personalised advice on diet and physical activity in young adults that perceive themselves to be a healthy weight versus those that perceive themselves to be overweight or 10 11 obese. An online survey of 396 young adults (18-25 years) evaluated background factors (participant characteristics (including perception of body weight), psychological factors, belief 12 composites) and constructs of the Theory of Planned Behaviour (TPB) related to the adoption 13 of genotype-based personalised advice. The association between background factors and TPB 14 constructs was assessed using multiple linear regression. The constructs of TPB predicted 15 intention to adopt genotype-based personalised nutrition (p < 0.001, adj. $R^2 = 0.54$; attitude: B 16 17 = 0.24, subjective norm: B = 0.25, PBC: B = 0.45). Background factors including belief composites, health locus of control, gender, physical activity, and food choice motives of 18 'health', 'price', 'familiarity', 'weight control', and 'convenience' significantly added to 19 models of TPB constructs related to the intention to adopt personalised advice (p < 0.05). The 20 21 influence of background factors varied between TPB constructs and differed based on participants perception of their body weight. The study provides support for the use of the TPB 22 in understanding the intention of young adults to adopt gene-based advice for dietary and 23 24 physical activity behaviour. In addition to perceived body weight, the background factors identified should help to inform and modify the delivery of advice in behaviour change 25 interventions that seek to use genotype-based personalised advice in young adult populations. 26

Keywords: Personalised nutrition; Intention; Theory of Planned Behaviour; Survey;
Nutrigenomics.

29

1 Introduction:

Modification of lifestyle behaviours, including diet and physical activity, can considerably reduce the prevalence of non-communicable diseases (NCD), reducing the burden of disease for both the individual and society¹. However, generic public health advice to address dietary and physical activity behaviours is not adhered to^{2,3}. Compared to this 'one size fits all' approach to dietary and physical activity advice, researchers have hypothesised that personalisation of advice based on an individual's genotype could motivate greater adherence to guidance⁴.

9 Genotype-based personalised advice is usually delivered in combination with other levels of 10 personalisation (phenotypic, clinical, dietary), with the aim to provide more precise and effective advice as well as to encourage behaviour change⁵. Studies that have investigated the 11 12 effect of genotype-based dietary advice on behaviour change have reported contradictory findings, both within and between studies^{6–9}. Recent systematic reviews and a meta-analysis of 13 studies that have investigated the effect of genotype-based advice to motivate dietary and 14 physical activity behaviour have reported no beneficial effect above that seen with other levels 15 of personalisation^{10,11}. However, one benefit of genotype-based personalisation of advice over 16 other levels of personalisation is that it can be delivered earlier in the lifespan, before unhealthy 17 lifestyle behaviours or metabolic and physiological conditions have developed. Therefore, 18 young people stand to benefit the most from genotype-based dietary and physical activity 19 advice^{12,13}. Furthermore, young people have been reported to be more likely to adopt 20 personalised nutrition compared to other age groups¹⁴. However, to effectively implement 21 22 genotype-based personalised advice to affect behaviour in young adults, an understanding of 23 factors that may encourage or prevent engagement is required.

24 Interventions designed to change health-related behaviours are more likely to be successful 25 when theoretical links between the intervention and the behaviour have been considered in the design^{12,15–17}. One of the most frequently cited behaviour change theories, the Theory of 26 Planned Behaviour (TPB)^{15,18}, states that 'intention' to perform a behaviour can be predicted 27 from three independent constructs: attitude toward the behaviour, subjective norms, and 28 perceived behavioural control (PBC)¹⁸. 'Attitude toward the behaviour' represents the extent 29 to which an individual has a favourable appraisal of that behaviour, 'subjective norms' is the 30 individual's perceived social pressure to perform or not perform the behaviour and 'PBC' is an 31 individual's perception of how easy or difficult it is to perform the behaviour¹⁹. Each construct 32

1 of the TPB is influenced by belief composites: behavioural beliefs, normative beliefs, and control beliefs¹⁸. Intention and PBC have been demonstrated to account for a significant 2 3 amount of variation in numerous health-related behaviours including food choice, multiple correlations ranging from 0.20 to 0.78^{18,20}. Furthermore, background factors such as 4 demographic characteristics, personality traits, and life values are reported to influence 5 intention to perform a behaviour by affecting TPB constructs¹⁹. There are several background 6 7 factors that previous research has identified that may influence intention to engage with 8 personalised advice: optimistic bias, the phenomenon by which an individual underestimates their own risk of developing a disease compared to others²¹; health locus of control (HLC), 9 whether an individual perceives their health to be under their control (internal) or not 10 (external)²²; food choice motives, nine factors that have been shown to influence food choice²³; 11 and participant characteristics, such as sex and personal history of NCD^{13,14,24–27}. 12

Although these factors have been associated previously with intention to engage with 13 14 personalised advice, an understanding of how TPB constructs, belief composites, and background factors relate to the intention to adopt genotype-based personalised nutrition 15 specifically in young adults has not been investigated. A clearer understanding of associations 16 between these background factors and the intention to utilise personalised advice would inform 17 researchers and health practitioners on how best to communicate advice to promote healthy 18 lifestyle behaviours. Therefore, the aim of the present study was to investigate the factors that 19 20 influence the intention to adopt genotype-based personalised advice for diet and physical activity in young adults; and to determine if factors differ in young adults that perceive 21 22 themselves to be a healthy weight and those that perceive themselves to be overweight or obese. The overall aim was broken down into two objectives presented in Figure 1. 23

24 [Figure 1]

25 Methods:

26 *Participants:*

A total of 414 responses were received for the survey, 18 were screened out due to not meeting the inclusion criteria. Therefore, 396 male and female young adults aged 18-25 years, living in the UK, who were not pregnant, lactating, following a restricted diet, or having a diagnosed eating disorder took part in the survey. Participants were recruited through advertisements shared during lectures at St Mary's University and social media postings (Facebook, Twitter and LinkedIn). Data were collected between March and November 2022 using the Jisc online 1 surveys platform (https:// www.onlinesurveys.ac.uk) to ensure data are stored in a secure and

2 GDPR compliant environment.

3 Survey development:

4 A pilot survey was conducted in 35 young adults (18-25 years) to assess the usability of the survey and develop the TPB questionnaire²⁸. Items used to measure the TPB constructs were 5 assessed for internal consistency²⁹ and discriminant validity³⁰. To measure belief composites, 6 7 free response questions were used to elicit behavioural outcomes and experiences (perceived 8 advantages, disadvantages and feelings), normative referents (individuals or groups that would 9 approve or disapprove), and control factors (factors that would make it easy or difficult) in 10 relation to the adoption of genotype-based advice to modify dietary or physical activity 11 behaviour. Content analysis of free response questions was used to construct items to be used in the final survey 28 (Supplementary material Table 1-3). 12

13 Final survey:

The final survey was divided into three sections. The first section asked participants about 14 characteristics: gender, age, ethnicity, education, perceived health, physical activity behaviour, 15 and their perceived body image. Physical activity was assessed using a single question to 16 17 determine whether participants were sufficiently active to benefit their health: 'In the past week, on how many days have you done a total of 30 min or more of physical activity, which 18 19 was enough to raise your breathing rate? This may include sport, exercise, and brisk walking or cycling for recreation or to get to and from places, but should not include housework or 20 physical activity that may be part of your job.'31. To measure perceived body image, 21 participants were asked to indicate their own body figure by choosing a silhouette of the 22 Stunkard Scale. Based on the selected silhouette participants were classed to perceive 23 themselves as underweight, normal weight, overweight or obese^{32–34}. 24

The second section asked participants about their HLC, motives for food choice, and optimistic 25 26 bias. For each scale, internal consistency was checked; Cronbach's alpha (α) for all factors indicated adequate internal consistency²⁹. To assess HLC, participants were asked to indicate 27 the extent to which they agreed or disagreed with six statements. For example: 'I can be as 28 healthy as I want to be.' Response: Completely disagree, Disagree, Neither disagree/nor agree, 29 Agree, Completely agree^{25,36}. The internal HLC was calculated from the average score for the 30 first three items ($\alpha = 0.77$) and external HLC from the second three items ($\alpha = 0.70$)³⁶. Motives 31 for food choice were measured using the Food Choice Questionnaire²³. The 36 items represent 32

nine factors and the mean score from 1-5 was calculated for each factor (health ($\alpha = 0.86$), 1 mood ($\alpha = 0.88$), convenience ($\alpha = 0.87$), sensory appeal ($\alpha = 0.82$), natural content ($\alpha = 0.88$), 2 price ($\alpha = 0.83$), weight control ($\alpha = 0.86$), familiarity ($\alpha = 0.74$), and ethical concern ($\alpha =$ 3 0.79). Optimistic bias was estimated by asking participants to respond to the following 4 5 statement 'How do you think your chances of getting cardiovascular disease in the future compare with those of the average adult of your age and sex? Response: 7-point Likert scale 6 (much lower than average - much higher than average)³⁷. Participants were also asked the same 7 8 question with reference to type 2 diabetes (T2D) and obesity. The mean score of all three items 9 was used to calculate overall optimistic bias ($\alpha = 0.86$), a higher score represented a higher 10 level of optimistic bias.

11 The final section of the survey asked participants how potential outcomes related to genotype-12 based personalised advice would increase the likelihood of adopting it²⁵. Also, items to 13 determine each construct of the TPB related to the adoption of genotype-based dietary and 14 physical activity advice. The direct measures of TPB constructs (attitude ($\alpha = 0.88$), subjective 15 norms ($\alpha = 0.77$), PBC ($\alpha = 0.81$) and intention ($\alpha = 0.87$) were calculated from the mean score 16 of items for each construct¹⁹. Belief composites (behavioural, normative, and control beliefs) 17 were calculated as described by Ajzen¹⁹.

18

19 *Statistical Analysis:*

Statistical analysis was carried out using IBM SPSS Statistics 26 for Windows (IBM Corp, 20 New York, USA). Measures of centrality and spread are presented as means and SD; 21 categorical data are presented as frequencies and percentages. Comparisons were made 22 23 between participants that perceived themselves to be normal weight and those that perceived themselves to be overweight or obese. Participants that perceived themselves to be underweight 24 25 were excluded from analysis (n = 5). Normality of data was assessed using the Shapiro-Wilk test. Baseline continuous measures were not normally distributed ($P \ge 0.05$) and were 26 compared between groups using a Mann-Whitney U test. Categorical variables were compared 27 28 using a Chi-square Test or when expected counts were less than five, a Fisher's Exact Test. For post hoc analyses, a Bonferroni adjustment was made to correct for multiple comparisons. 29 30 Stepwise linear multiple regression analysis was conducted to identify the relationship between 31 constructs of the TPB and intention to adopt genotype-based personalised nutrition, and to 32 determine the relationship between behavioural beliefs, food choice motives, characteristics and psychological factors, with each construct of the TPB. Each multiple regression was 33

1 conducted with all participants and separately in those that perceived themselves to be normal 2 weight and those that perceived themselves to be overweight or obese. All tests were two-tailed 3 and considered statistically significant when P < 0.05.

4 **Results:**

5 *Participant characteristics:*

A total of 396 young adults completed the survey; their characteristics are summarised in 6 7 Table 1. Seventy six percent of participants perceived themselves to be normal weight, with 8 23% overweight or obese, and one percent underweight. Compared to participants that perceived themselves to be normal weight, participants that perceived themselves to be 9 10 overweight were more likely to be male (54% v 46%, P = 0.001) and reported to be physically active less frequently (3.4 v 4.2 days / week, P = 0.001). There was also a significant difference 11 between proportions for how healthy participants considered themselves (P < 0.001). 12 Compared to participants that perceived themselves to be overweight or obese, a greater 13 proportion of participants that perceived themselves to be normal weight considered 14 15 themselves to be very healthy compared to healthy, moderately healthy, or unhealthy. Also, a greater proportion considered themselves to be healthy compared to unhealthy. There was no 16 significant difference between the proportion of participants that perceived themselves to be 17 overweight or obese versus those that perceived themselves to be normal weight, based on their 18 age (, P = 0.475), ethnicity (P = 0.063), country of residence (P = 0.179), or highest level of 19 education that they had completed (P = 0.317). 20

21 [Table 1]

22 Psychological factors, motives for food choice, and constructs of the TPB

Mean scores for psychological factors, motives for food choice, and constructs of the TPB were 23 24 compared between participants that perceived themselves to be normal weight and participants that perceived themselves to be overweight or obese. Participants that perceived themselves to 25 be overweight or obese had a significantly lower internal HLC (3.8 v 4.0, P = 0.002), overall 26 optimistic bias (4.2 v 5.2, P < 0.001), and optimistic bias for developing cardiovascular disease 27 (CVD) (4.3 v 5.0, *P* < 0.001), T2D (4.2 v 5.1, *P* < 0.001) and obesity (4.2 v 5.6, *P* < 0.001). 28 29 There were no significant differences between groups for external HLC, food choice motives, or constructs of the TPB ($P \ge 0.05$). Sensory appeal was the highest rated food choice motive, 30 followed by price and health. Mean scores for attitude, subjective norms and PBC were positive 31 32 (Table 2).

1 [Table 2]

2 *Objective 1: TPB constructs and intention.*

- 3 Multiple regression analysis revealed that attitude, subjective norm, and PBC explained the
- 4 intention to adopt genotype-based personalised nutrition for all participants (P < 0.001, adj. R^2
- 5 = 0.54; attitude: B = 0.24, subjective norm: B = 0.25, PBC: B = 0.45), those that perceived
- 6 themselves to be normal weight (P < 0.001, adj. $R^2 = 0.58$; attitude: B = 0.25, subjective norm:
- 7 B = 0.25, PBC: B = 0.46), and those that perceived themselves to be overweight or obese (P <
- 8 0.001, adj. $R^2 = 0.40$; attitude: B = 0.23, subjective norm: B = 0.24, PBC: B = 0.38). In all
- 9 models the largest unstandardised regression coefficient was observed for PBC, followed by
- 10 subjective norm and attitude which was not a significant predictor in the model for participants
- 11 that perceive themselves to be overweight or obese (Figure 2, Supplementary Table 6).
- 12 [Figure 2]
- 13 *Objective 2:*
- 14 Belief composites and TPB constructs
- 15 Belief composites explained attitude, subjective norms and PBC towards genotype-based
- personalised advice in all participants (P < 0.001, adj. $R^2 = 0.49$; P < 0.001, adj. $R^2 = 0.20$; P
- 17 < 0.001, adj. $R^2 = 0.08$), participants that perceived themselves to be normal weight (P < 0.001,
- 18 adj. $R^2 = 0.49$; P < 0.001, adj. $R^2 = 0.18$; P < 0.001, adj. $R^2 = 0.10$), and participants that
- 19 perceived themselves to be overweight or obese (P < 0.001, adj. $R^2 = 0.48$; P < 0.001, adj. R^2
- 20 = 0.23; F = 4.151, P = 0.045, adj. $R^2 = 0.03$) (Figure 3, Supplementary Table 7-9).
- 21 [Figure 3]
- 22 Psychological factors, characteristics and TPB constructs

Psychological factors and characteristics explained attitude, subjective norms, and PBC in all participants (P < 0.001, adj. $R^2 = 0.11$; P < 0.001, adj. $R^2 = 0.03$; P < 0.001, adj. $R^2 = 0.12$), in participants that perceived themselves to be normal weight (P < 0.001, adj. $R^2 = 0.13$; P < 0.001, adj. $R^2 = 0.07$; p < 0.001, adj. $R^2 = 0.13$) and, in participants that perceived themselves

- to be overweight or obese (p = 0.001, adj. $R^2 = 0.10$; P = 0.042, adj. $R^2 = 0.03$; P = 0.028, adj.
- 28 $R^2 = 0.04$) (Figure 4, Supplementary Table 10-12).
- 29 [Figure 4]
- 30 Food choice motives and TPB constructs

Food choice motives predicted attitude, subjective norms and PBC in all participants (P < 0.001, adj. $R^2 = 0.10$; P = 0.001, adj. $R^2 = 0.03$; P < 0.001, adj. $R^2 = 0.11$), in participants that perceived themselves to be normal weight (P < 0.001, adj. $R^2 = 0.06$; P = 0.013, adj. $R^2 = 0.02$; P < 0.001, adj. $R^2 = 0.08$) and participants that perceived themselves to be overweight or obese (P < 0.001, adj. $R^2 = 0.20$; P = 0.032, adj. $R^2 = 0.04$; P = 0.001, adj. $R^2 = 0.15$) (Figure 5,

- 6 Supplementary Table 13-15).
- 7 [Figure 5]
- 8

9 **Discussion**

The aim of this research was to use the TPB as a model to understand the intentions of young 10 adults to adopt genotype-based personalised advice for dietary or physical activity behaviour. 11 On average, young adults have a positive intention to adopt genotype-based advice for dietary 12 and physical activity behaviour, driven by a favourable attitude, a positive perception of social 13 pressure, and perceived ability to perform the behaviour. These findings were consistent in 14 participants that perceived themselves to be normal weight and overweight or obese. To 15 16 understand the factors that influence the proximal constructs of intention to adopt genotypebased personalised advice, the relationships between belief composites, characteristics and 17 psychological factors, and food choice motives were determined for each construct. 18

19 Attitude towards the behaviour

Behavioural beliefs of 'motivation to eat healthily and exercise' and 'prevent disease' were 20 significant positive predictors of attitude in all models. 'To achieve health and fitness goals' 21 22 was a significant positive predictor of attitude for all participants and participants that perceive themselves to be normal weight; however, 'worry about the risk of developing a disease' was 23 24 a significant positive predictor for all participants and those that perceived themselves to be overweight or obese. Consequently, when implementing an intervention in young adults that 25 26 do not perceive themselves to be overweight, highlighting personalised advice as a tool to 27 improve health and fitness may increase uptake, whereas in a population that deem themselves 28 to be overweight it may be more effective to highlight the role of personalised advice in disease prevention. 29

Having an external HLC was a significant negative predictor of attitude towards adoption of
genotype-based advice. However, the low mean external HLC score suggested that the majority

1 of participants perceived health to be under their control and scores did not differ significantly between participants based on their body weight perception. Previous research has suggested 2 that internal HLC had a greater capacity to explain variance in diet-related behaviour than 3 external HLC³⁸. Internal HLC was significantly positively associated with attitude in the 4 5 present study (r = 0.12) but did not add significantly to the model; furthermore, the negative relationship between external HLC and attitude was stronger (r = -0.34). Poínhos et al.²⁴ also 6 7 reported a stronger association between external, compared to internal, HLC and attitude. 8 Therefore, when investigating personalised nutrition, it appears that external rather than 9 internal HLC has a greater capacity to explain variance in attitude. In the present study, internal HLC was significantly lower in participants that perceived themselves to be overweight or 10 obese compared to those that perceived themselves to be normal weight. Consequently, 11 challenging the perception of young adults that their health is not under their control could 12 improve their attitude towards genotype-based personalised advice. In participants that 13 perceived themselves to be normal weight, men had a significantly less positive attitude 14 towards personalised nutrition than women. Women have been reported to be more conscious 15 of health and demonstrate greater engagement with preventative behaviours³⁹. In contrast, men 16 have been reported to have lower adherence to, and belief in, healthy eating 17 recommendations⁴⁰, and are less likely to be willing to have a genetic test^{26,41}. In effect, for 18 many aspects of genotype-based personalised nutrition, the advice provided may be more 19 effective if it is personalised by sex^{42,43}. Consequently, the findings of the present study are in 20 agreement with the recommendation that interventions to change health behaviours should be 21 developed differently for male and female populations³⁹. 22

Food choice motives explained the greatest percentage of variance in the model which included 23 24 participants that perceived themselves to be overweight or obese (20%) compared to the model 25 which included participants that perceived themselves to be normal weight (6%). In all models, 26 'health' had the largest B-coefficient, and this was greatest in the model of participants that perceived themselves to be overweight or obese. Previous research has highlighted a positive 27 association with the food choice motive of 'health' and attitude towards both healthy eating in 28 young adults⁴⁴ and attitude towards personalised nutrition in European adults³⁵. In the present 29 study, 'health' was the third highest rated food choice motive after 'sensory appeal' and 'price'. 30 'Sensory appeal' and 'price' are commonly reported as the highest rated motives for food 31 choice^{22,44}. Consequently, for health motives to be considered in food choice, the food should 32 33 have sensory appeal and good value. In accordance with previous research, participants that

rated 'familiarity' as an important motive for food choice had a less favourable attitude towards 1 genotype-based advice³⁵. These participants may perceive that genotype-based advice would 2 require them to consume new or different foods to those they normally eat. Eating context has 3 been investigated in previous research and may overlap with the concept of familiarity^{13,25,45}. 4 5 Eating context may be a barrier to the adoption of personalised nutrition, particularly when eating out of the home or with family members^{13,25,45}. Therefore, young adults may have a more 6 7 favourable attitude towards the use personalised advice if they are assured that food preferences 8 and eating context will be considered in the advice 35,45 .

9 Subjective norms

In all models 'health professionals' were a significant positive predictor of subjective norms.
In line with other research, communication of information to young adults about the benefits
of personalised dietary and physical activity advice may be most effective when delivered by
a health professional^{23,46}.

Male participants and those that perceived that their health was outside of their own control were less influenced by perceived social pressure to engage with genotype-based personalised dietary or physical activity advice. In participants that perceived themselves to be overweight or obese, a higher level of reported physical activity was associated with lower subjective norms. Since these participants are already engaged in healthy lifestyle behaviours, they may be influenced less by social pressure.

As reported with attitude towards the behaviour, a similar pattern was observed between food 20 choice motives of 'health' (significant positive relationship) and 'familiarity' (significant 21 negative relationship) with subjective norms. However, in participants that perceived 22 23 themselves to be overweight or obese, 'weight control' was the only significant predictor of subjective norms. Participants who reported 'weight control' as a strong motive in their food 24 choice were more influenced by social pressure to engage with genotype-based personalised 25 advice. Previous research has identified the potential for weight loss as a perceived benefit of 26 personalised nutrition²⁵ as well as being a significant predictor of attitude, intention³⁵ and 27 acceptance of personalised nutrition advice⁴⁷. 28

29 Perceived behavioural control

Control beliefs explained a significant proportion of the variance in PBC in all models,
although the percentage of variance explained was trivial (3-10%). 'Having enough money'

was a significant positive predictor in all models and 'having confidence in the effectiveness 1 2 of guidance' was a positive predictor in the model including all participants and those that perceived themselves to be normal weight. Previous research has reported perceived benefits 3 of personalised advice to have the strongest relationship with attitude, intention^{24,45,48}, and 4 acceptance⁴⁷ of personalised nutrition. Confidence in the effectiveness of guidance may 5 represent a proportion of what participants would perceive as benefits of personalised advice. 6 7 Conversely, perceived risk (not measured in the present study) has been reported to have a negative, although less influential, relationship with attitude and intention^{24,48}. 8

9 Participants that perceived greater control over their own health perceived themselves to have
10 greater control over their health-related behaviour. The consistent finding between external
11 HLC and each construct of the TPB once again highlights the importance of communicating
12 how lifestyle behaviour can be as important as genetics in determining the risk of disease⁴⁹ and,
13 in terms of increasing PBC, explaining how individuals can achieve or maintain healthy
14 behaviours.

Food choice motives of 'health', 'price' and 'familiarity' influenced participant's perception 15 of their ability to adopt genotype-based personalised advice to modify their dietary or physical 16 17 activity behaviour, in a similar manner to attitude and subjective norms. 'Convenience' had a significant negative relationship in the model for all participants and those that perceived 18 themselves to be overweight or obese. Participants that rate 'convenience' as a strong motive 19 for food choice may perceive the adoption of dietary or physical activity advice to be more 20 challenging. 'Convenience' was not identified as a significant factor in the study by Rankin et 21 al.³⁵ and this may be because they only looked at the relationship between food choice motives 22 23 and attitude and intention to adopt personalised nutrition. The findings of the present study 24 suggest that although there are some consistent patterns between food choice motives and TPB 25 constructs, there are also differences both between constructs and between participants based on their perception of their body weight. An understanding of which factors influence which 26 27 constructs of the TPB helps to understand the context of how advice should be communicated 28 to young adults. For example, whether it should be phrased to address their appraisal of 29 genotype-based advice (attitude) or their ability to carry out necessary changes in their 30 behaviour (PBC).

1 *Recommendations*

There are some recommendations for the delivery of genotype-based personalised advice to 2 3 motivate healthy dietary and physical activity behaviour in young adults that appear to be generically applicable to this population. To appreciate the need to meet advice, young adults 4 need to accept the strong effect that these lifestyle behaviours can have on their subsequent 5 health and, importantly, that this is under their control. Advice provided should be delivered in 6 the context of improving health. Food preferences should be considered in the delivery of 7 8 dietary recommendations and advice should preferably be delivered via a health professional. 9 Advice should detail how to meet dietary and physical activity advice; for example, if a 10 reduction in sodium intake is recommended, advice should explain which foods are high in salt and provide alternative food choices to enable the advice to be met. The findings also suggest 11 12 that to motivate behaviour change, advice should be tailored based on individual characteristics of young adults. Highlighting the role of genotype-based advice to improve health and fitness 13 14 is more important for young adults that perceive themselves to be normal weight; whereas, in young adults that perceive themselves to be overweight or obese, advice for disease prevention 15 and weight control would likely be more effective for increasing their intention to adopt advice. 16 17 Of participants that perceive themselves to be normal weight, young men had a less favourable attitude towards the adoption of genotype-based dietary and physical activity advice and were 18 less influenced by social pressure than young women. Therefore, advice that increases their 19 perceived ability to adopt dietary and physical activity advice may be more effective in 20 increasing their intention to adopt advice. Young adults that believe they are already engaged 21 in healthy lifestyle behaviours or perceive themselves to be normal weight are less likely to 22 perceive a need to adopt genotype-based advice²⁰. Optimistic bias has been suggested as a 23 potential barrier to the adoption of personalised nutrition advice, particularly in younger 24 25 populations¹³. Although optimistic bias did not add significantly to any of the models, it was 26 significantly higher in the participants that perceived themselves to be normal weight and was 27 correlated significantly with participants' health perception (r = 0.33), physical activity (r =0.34), internal HLC (r = 0.35), and external HLC (r = -0.25). Advice provided to this group 28 should highlight how genes can interact with lifestyle behaviours to affect disease risk, in order 29 to challenge their optimistic bias. Adoption of these recommendations would provide more 30 targeted personalised advice to young adults and as a consequence may result in a more 31 effective intervention to change behaviour. 32

1 *Strengths and limitations*

2 The strengths of this study include a specific focus on a young adult population who stand to benefit most from genotype-based personalised advice. The use of the TPB provided a 3 framework to understand the factors that influence the intention to adopt genotype-based 4 personalised advice. The relationship between background factors and subjective norms and 5 PBC in addition to attitude was included and was novel to this research area. However, the 6 study was not without limitations; in several of the regression models, despite being significant, 7 8 only a small amount of variance was explained by the factors included. Control beliefs were determined from salient beliefs elicited in the pilot study and explained less than 10% of the 9 variance in PBC; in effect, there may be further control factors that make up PBC in this young 10 adult population. Other potential background factors that may have influenced TPB constructs, 11 12 and intention to adopt genotype-based advice were not included; the most important of which 13 was a measure of risk and benefit. This has been previously well researched with the relatively consistent finding that benefits have a greater influence than risks on intention to adopt 14 genotype-based advice^{13,24,45,47,48,50}. Since the risk/benefit relationship with adoption of 15 personal nutrition is relatively well understood, it was not included as a measure in the present 16 study; however, it may account for a proportion of the unexplained variance in the models. 17

18

19 *Conclusions*

In conclusion, the current study provides support for the use of the TPB in understanding the 20 intention of young adults to adopt genotype-based advice for dietary and physical activity 21 behaviour. Background factors including belief composites, HLC, gender, physical activity, 22 and food choice motives of 'health', 'price', 'familiarity', 'weight control', and 'convenience' 23 interact with TPB constructs. In addition to perceived body weight, these background factors 24 25 should be utilised to inform the delivery of advice in behaviour change interventions that seek to use genotype-based personalised advice in young adult populations. Finally, the 26 recommendations for the use of genotype-based dietary and physical activity advice in young 27 adults, based on the findings of the present study, need to be evaluated in a genotype-based 28 personalised nutrition intervention study to change dietary behaviour. 29

30

1 2

Acknowledgements: Not applicable

3 Financial Support: Not applicable

4

5 Conflict of Interest: YM is a scientific consultant for MyHealthChecked, a wellness 6 company that uses genetic testing. LP is founder of Optimyse Nutrition, a nutritional advice 7 company that offers genetic testing. KL previously held a paid role as Research Editor for 8 Foodsmatter. She is an Editorial Board Member for the British Association of Nutritional and 9 Lifestyle Medicine, Nutritional Evidence Database (NED) and a Scientific Advisory Board 10 Member for Chuckling Goat, both in an unpaid capacity. She is occasionally paid, or receives hospitality, to deliver talks on her research and infrequently receives sample products related 11 to health and nutrition. 12 13 14 **Authorship:** AK: formulating the research question, designing the study, carrying out study, analysing the data and writing the article – original draft. YM, LP, MG and KL - formulating 15

16 the research question, designing the study and writing the article – review and editing. All

- 17 authors read and approved the final manuscript.
- 18

Ethical Standards Disclosure: This study was conducted according to the guidelines laid
down in the Declaration of Helsinki and all procedures involving research study participants
were approved by the St Mary's University Research Ethics Sub-Committee (SMEC_202223_027). Informed consent was obtained from all participants.

23 **References:**

- Ezzati M, Hoorn SV, Rodgers A, et al. Estimates of global and regional potential health gains
 from reducing multiple major risk factors. Lancet 2003;362(9380):271–280; doi: 10.1016/s0140 6736(03)13968-2.
- Health Survey for England. Health Survey for England, 2016. 2017. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-forengland/health-survey-for-england-2016 [Last accessed: 7/3/2021].
- Roberts C, Steer T, Maplethorpe L, et al. National Diet and Nutrition Survey Results from Years
 7 and 8 (Combined) of the Rolling Programme (2014/2015 to 2015/2016). 2018.
- Celis-Morales C, Lara J, Mathers JC. Personalising nutritional guidance for more effective behaviour change. Proceedings of the Nutrition Society 2015;74(2):130–138; doi: 10.1017/S0029665114001633.

- Grimaldi KA, van Ommen B, Ordovas JM, et al. Proposed guidelines to evaluate scientific
 validity and evidence for genotype-based dietary advice. Genes Nutr 2017;12:35; doi:
 10.1186/s12263-017-0584-0.
- Celis-Morales C, Livingstone KM, Marsaux CF, et al. Effect of personalized nutrition on healthrelated behaviour change: evidence from the Food4Me European randomized controlled trial. Int J Epidemiol 2017;46(2):578–588; doi: 10.1093/ije/dyw186.
- 7 7. Horne J, Gilliland J, O'Connor C, et al. Enhanced long-term dietary change and adherence in a nutrigenomics-guided lifestyle intervention compared to a population-based (GLB/DPP) lifestyle intervention for weight management: results from the NOW randomised controlled trial. BMJ
 10 Nutrition, Prevention & Health 2020;bmjnph-2020-000073; doi: 10.1136/bmjnph-2020-000073.
- King A, Saifi S, Smith J, et al. Does personalised nutrition advice based on apolipoprotein E and methylenetetrahydrofolate reductase genotype affect dietary behaviour? Nutr Health 2022;28(3):467–476; doi: 10.1177/02601060211032882.
- Nielsen DE, El-Sohemy A. Disclosure of genetic information and change in dietary intake: a randomized controlled trial. PLoS ONE 2014;9(11):e112665; doi: 10.1371/journal.pone.0112665.
- 16 10. King A, Graham CA-M, Glaister M, et al. The efficacy of genotype-based dietary or physical
 activity advice in changing behavior to reduce the risk of cardiovascular disease, type II diabetes
 mellitus or obesity: a systematic review and meta-analysis. Nutr Rev 2023;nuad001; doi:
 19 10.1093/nutrit/nuad001.
- 11. Jinnette R, Narita A, Manning B, et al. Does Personalized Nutrition Advice Improve Dietary
 Intake in Healthy Adults? A Systematic Review of Randomized Controlled Trials. Advances in
 Nutrition 2020;(nmaa144); doi: 10.1093/advances/nmaa144.
- 12. NICE. Overview | Behaviour Change: General Approaches | Guidance | NICE. 2007. Available
 from: https://www.nice.org.uk/Guidance/PH6 [Last accessed: 7/10/2019].
- Stewart-Knox BJ, Kuznesof S, Robinson J, et al. Factors influencing European consumer uptake
 of personalised nutrition. Results of a qualitative analysis. Appetite 2013;66:67–74; doi:
 10.1016/j.appet.2013.03.001.
- 14. Stewart-Knox BJ, Poínhos R, Fischer ARH, et al. Sex and age differences in attitudes and intention to adopt personalised nutrition in a UK sample. Z Gesundh Wiss 2021;1–7; doi: 10.1007/s10389-021-01676-x.
- 31 15. Davis R, Campbell R, Hildon Z, et al. Theories of behaviour and behaviour change across the
 32 social and behavioural sciences: a scoping review. Health Psychol Rev 2015;9(3):323–344; doi:
 33 10.1080/17437199.2014.941722.
- Horne J, Madill J, Gilliland J. Incorporating the "Theory of Planned Behavior" into personalized
 healthcare behavior change research: a call to action. Per Med 2017;14(6):521–529; doi:
 10.2217/pme-2017-0038.
- Timlin D, McCormack JM, Kerr M, et al. Are dietary interventions with a behaviour change
 theoretical framework effective in changing dietary patterns? A systematic review. BMC Public
 Health 2020;20(1):1857; doi: 10.1186/s12889-020-09985-8.
- 40 18. Ajzen I. The Theory of Planned Behavior. Organizational Behavior and Human Decision
 41 Processes 1991;50(2):179–211; doi: 10.1016/0749-5978(91)90020-T.

- Ajzen I. The Theory of Planned Behavior: Frequently asked questions. Human Behavior and Emerging Technologies 2020;2(4):314–324; doi: 10.1002/hbe2.195.
- McDermott MS, Oliver M, Svenson A, et al. The theory of planned behaviour and discrete food
 choices: a systematic review and meta-analysis. Int J Behav Nutr Phys Act 2015;12:162; doi:
 10.1186/s12966-015-0324-z.
- Shepherd R. Social determinants of food choice. Proceedings of the Nutrition Society
 1999;58(4):807–812; doi: 10.1017/S0029665199001093.
- 8 22. Wallston BS, Wallston KA, Kaplan GD, et al. Development and validation of the Health Locus of
 9 Control (HLC) Scale. Journal of Consulting and Clinical Psychology 1976;44(4):580; doi:
 10 10.1037/0022-006X.44.4.580.
- Steptoe A, Pollard TM, Wardle J. Development of a Measure of the Motives Underlying the
 Selection of Food: the Food Choice Questionnaire. Appetite 1995;25(3):267–284; doi:
 10.1006/appe.1995.0061.
- Bayer S, Drabsch T, Schauberger G, et al. Knowledge, opinions and expectations of adults
 concerning personalised genotype-based dietary recommendations: a German survey. Public
 Health Nutr 2021;24(7):1916–1926; doi: 10.1017/S1368980020004152.
- Poínhos R, Lans IA van der, Rankin A, et al. Psychological Determinants of Consumer
 Acceptance of Personalised Nutrition in 9 European Countries. PLOS ONE 2014;9(10):e110614;
 doi: 10.1371/journal.pone.0110614.
- 26. Rankin A, Kuznesof S, Frewer LJ, et al. Public perceptions of personalised nutrition through the
 lens of Social Cognitive Theory. J Health Psychol 2017;22(10):1233–1242; doi:
 10.1177/1359105315624750.
- 27. Vallée Marcotte B, Cormier H, Garneau V, et al. Nutrigenetic Testing for Personalized Nutrition:
 An Evaluation of Public Perceptions, Attitudes, and Concerns in a Population of French
 Canadians. LFG 2018;11(3–6):155–162; doi: 10.1159/000499626.
- 26 28. Ajzen I. Constructing a Theory of Planned Behaviour Questionnaire. 2006;7.
- 27 29. Tavakol M, Dennick R. Making sense of Cronbach's alpha. Int J Med Educ 2011;2:53–55; doi: 10.5116/ijme.4dfb.8dfd.
- 30. Henseler J, Ringle CM, Sarstedt M. A new criterion for assessing discriminant validity in
 variance-based structural equation modeling. J of the Acad Mark Sci 2015;43(1):115–135; doi:
 10.1007/s11747-014-0403-8.
- 31. Milton K, Clemes S, Bull F. Can a single question provide an accurate measure of physical activity? Br J Sports Med 2013;47(1):44–48; doi: 10.1136/bjsports-2011-090899.
- 34 32. Parzer V, Sjöholm K, Brix JM, et al. Development of a BMI-Assigned Stunkard Scale for the
 Evaluation of Body Image Perception Based on Data of the SOS Reference Study. OFA
 2021;14(4):397–404; doi: 10.1159/000516991.
- 37 33. Stunkard AJ, Sørensen T, Schulsinger F. Use of the Danish Adoption Register for the study of
 38 obesity and thinness. Res Publ Assoc Res Nerv Ment Dis 1983;60:115–120.

- 34. Thompson JK, Altabe MN. Psychometric Qualities of the Figure Rating Scale. International Journal of Eating Disorders 1991;10(5):615–619; doi: 10.1002/1098-108X(199109)10:5<615::AID-EAT2260100514>3.0.CO;2-K.
- 35. Rankin A, Bunting BP, Poínhos R, et al. Food choice motives, attitude towards and intention to adopt personalised nutrition. Public Health Nutr 2018;21(14):2606–2616; doi:
 10.1017/S1368980018001234.
- 36. Gebhardt WA. The Revised Health Hardiness Inventory (RHHI-24): psychometric properties and relationship with self-reported health and health behavior in two Dutch samples. Health
 Education Research 2001;16(5):579–592; doi: 10.1093/her/16.5.579.
- Klein W. Optimistic Bias | Division of Cancer Control and Population Sciences (DCCPS). 2020.
 Available from: https://cancercontrol.cancer.gov/brp/research/constructs/optimistic-bias [Last accessed: 11/15/2022].
- 13 38. Cohen M, Azaiza F. Health-promoting behaviors and health locus of control from a multicultural
 perspective. Ethn Dis 2007;17(4):636–642.
- 39. Hiller J, Schatz K, Drexler H. Gender influence on health and risk behavior in primary
 prevention: a systematic review. Z Gesundh Wiss 2017;25(4):339–349; doi: 10.1007/s10389-0170798-z.
- 40. Wardle J, Haase AM, Steptoe A, et al. Gender differences in food choice: The contribution of health beliefs and dieting. ann behav med 2004;27(2):107–116; doi: 10.1207/s15324796abm2702_5.
- 41. Stewart-Knox BJ, Bunting BP, Gilpin S, et al. Attitudes toward genetic testing and personalised
 nutrition in a representative sample of European consumers. Br J Nutr 2009;101(7):982–989; doi:
 10.1017/S0007114508055657.
- 42. Corella D, Coltell O, Portolés O, et al. A Guide to Applying the Sex-Gender Perspective to Nutritional Genomics. Nutrients 2018;11(1):4; doi: 10.3390/nu11010004.
- 43. Winkler TW, Justice AE, Graff M, et al. The Influence of Age and Sex on Genetic Associations
 with Adult Body Size and Shape: A Large-Scale Genome-Wide Interaction Study. Adeyemo A.
 ed. PLOS Genetics 2015;11(10):e1005378; doi: 10.1371/journal.pgen.1005378.
- 44. Sun Y-HC. Health concern, food choice motives, and attitudes toward healthy eating: The
 mediating role of food choice motives. Appetite 2008;51(1):42–49; doi:
 10.1016/j.appet.2007.11.004.
- 45. Reinders MJ, Bouwman EP, van den Puttelaar J, et al. Consumer acceptance of personalised
 nutrition: The role of ambivalent feelings and eating context. PLoS One 2020;15(4):e0231342;
 doi: 10.1371/journal.pone.0231342.
- 46. Fallaize R, Macready AL, Butler LT, et al. The perceived impact of the National Health Service
 on personalised nutrition service delivery among the UK public. Br J Nutr 2015;113(8):1271–
 1279; doi: 10.1017/S0007114515000045.
- 47. Bouwman EP, Reinders MJ, Galama J, et al. The Impact of Both Individual and Contextual
 Factors on the Acceptance of Personalized Dietary Advice. Nutrients 2022;14(9):1866; doi:
 10.3390/nu14091866.

- 48. Berezowska A, Fischer ARH, Ronteltap A, et al. Consumer adoption of personalised nutrition
 services from the perspective of a risk-benefit trade-off. Genes Nutr 2015;10(6):42; doi:
 10.1007/s12263-015-0478-y.
- 4 49. Khera AV, Emdin CA, Drake I, et al. Genetic Risk, Adherence to a Healthy Lifestyle, and
 5 Coronary Disease. New England Journal of Medicine 2016;375(24):2349–2358; doi:
- 6 10.1056/NEJMoa1605086.
- 50. Berezowska A, Fischer ARH, Trijp HCM van. The moderating effect of motivation on healthrelated decision-making. Psychol Health 2017;32(6):665–685; doi:
 10.1080/08870446.2017.1293055.

Characteristic		Normal weight		Overweight or obese		All participants		P value
		n or mean	% or SD	n or mean	% or SD	n or mean	% or SD	
Gender	Men	103	34	50	54	153	39	<i>P</i> = 0.001
	Women	196	66	42	46	243	61	
Age	(years)	21	2	21	2	21	2	P = 0.475
Ethnicity	Asian or Asian British	29	10	17	19	46	12	P = 0.063
	Black, Black British, Caribbean or African	27	9	8	9	35	9	
	Mixed or multiple ethnic groups	18	6	8	9	27	7	
	White	214	72	53	58	271	68	
	Other ethnic group	11	4	6	7	17	4	
Country of residence	England	293	98	87	95	385	97	P = 0.179
	Wales	1	0	1	1	2	1	
	Scotland	2	1	1	1	3	1	
	Northern Ireland	3	1	3	3	6	2	
Education	Secondary School (GCSE or equivalent)	9	3	4	4	14	4	P = 0.317
	Further Education (A Level or equivalent)	187	63	53	58	243	61	
	Bachelor's Degree	86	29	26	28	112	28	
	Master's Degree	16	5	7	8	24	6	
	Prefer not to say	1	0	2	2	3	1	
Health Perception	Very unhealthy	3	1	2	2	5	1	<i>P</i> < 0.001
	Unhealthy	5	2	9	10	14	4	
	Moderately unhealthy	48	16	27	29	77	19	
	Healthy	198	66	53	58	253	64	
	Very healthy	45	15	1	1	47	12	
Physical activity	(days/week)	4.2	1.9	3.4	1.9	4.0	2.0	P = 0.001
Perceived body image	Underweight	0	0	0	0	5	1	
_	Normal weight	299	100	0	0	299	76	
	Overweight	0	0	75	82	75	19	
	Obese	0	0	17	19	17	4	

Table 1. Characteristics for all participants (n = 396), and for those that perceive themselves to be normal weight (n = 299) and those that perceive themselves to be overweight or obese (n = 92) data presented as n (%) or mean and SD.

Table 2. Psychological factors, motives for food choice and constructs of the Theory of Planned Behaviour for all participants (n = 396), and for those that perceive themselves to be normal weight (n = 299) and those that perceive themselves to be overweight or obese (n = 92); data presented as mean and SD.

	Normal weight		Overweight or obese		All participants	
	mean	SD	mean	SD	mean	SD
Internal Health locus of control	4.0	0.6	3.8*	0.8	4.0	0.7
External Health locus of control	1.7	0.6	1.8	0.7	1.7	0.6
Optimistic bias	5.2	1.3	4.2*	1.3	5.0	1.4
CVD	5.0	1.3	4.3*	1.4	4.9	1.4
T2D	5.1	1.5	4.2*	1.5	4.9	1.5
Obesity	5.6	1.3	4.2*	1.8	5.3	1.6
Food choice motives						
Health	3.5	0.7	3.4	0.8	3.5	0.7
Mood	3.3	0.9	3.4	0.8	3.3	0.9
Convenience	3.2	0.8	3.2	1.0	3.1	0.9
Sensory appeal	3.7	1.0	3.6	0.9	3.7	0.8
Natural content	3.1	0.8	2.9	1.1	3.0	1.0
Price	3.5	0.8	3.6	0.8	3.6	0.9
Weight control	2.8	1.0	3.0	1.1	2.8	1.1
Familiarity	2.5	0.9	2.5	0.9	2.5	0.9
Ethical concern	2.2	0.9	2.1	0.9	2.1	0.9
TPB constructs						
Attitude	5.0	1.1	4.9	1.2	5.0	1.1
Subjective Norms	4.8	1.1	4.6	1.3	4.7	1.2
Perceived Behavioural Control	4.8	1.1	4.7	1.0	4.8	1.1
Intention	4.5	1.3	4.5	1.2	4.5	1.3

CVD, cardiovascular disease; T2D, type 2 diabetes; TPB, theory of planned behaviour; *significantly different to participants that perceive themselves to have a normal body weight P < 0.05.

Figure 1. Specification of theory of planned behaviour model and study objectives.

Figure 2. Objective 1: Summary of unstandardized regression coefficients and adjusted R^2 of constructs of the Theory of Planned Behaviour, for all participants, participants that perceive themselves to be normal weight and participants that perceive themselves to be overweight or obese.

B, unstandardized regression coefficient; adj. R^2 , adjusted R^2 ; SN, subjective norms; PBC, perceived behavioural control; All, all participants (n = 391); NW, participants that perceive themselves to be normal weight (n = 299); OW, participants that perceive themselves to be overweight or obese (n = 92). * P < 0.001; ** P < 0.05.

Figure 3. Objective 2: Summary of unstandardized regression coefficients and adjusted R^2 of constructs of belief composites and Theory of Planned Behaviour constructs, for all participants, participants that perceive themselves to be normal weight and participants that perceive themselves to be overweight or obese.

B, unstandardized regression coefficient; adj. R^2 , adjusted R^2 ; SN, subjective norms; PBC, perceived behavioural control; All, all participants (n = 391); NW, participants that perceive themselves to be normal weight (n = 299); OW, participants that perceive themselves to be overweight or obese (n = 92). * P < 0.001; ** P < 0.05.

Figure 4. Objective 2: Summary of unstandardized regression coefficients and adjusted R^2 of psychological factors and characteristics for Theory of Planned Behaviour constructs, for all participants, participants that perceive themselves to be normal weight and participants that perceive themselves to be overweight or obese.

B, unstandardized regression coefficient; adj. R^2 , adjusted R^2 ; SN, subjective norms; PBC, perceived behavioural control; All, all participants (n = 391); NW, participants that perceive themselves to be normal weight (n = 299); OW, participants that perceive themselves to be overweight or obese (n = 92). * P < 0.001; ** P < 0.05.

Figure 5. Objective 2: Summary of unstandardized regression coefficients and adjusted R^2 of food choice motives for Theory of Planned Behaviour constructs, for all participants, participants that perceive themselves to be normal weight and participants that perceive themselves to be overweight or obese.

B, unstandardized regression coefficient; adj. R^2 , adjusted R^2 ; SN, subjective norms; PBC, perceived behavioural control; All, all participants (n = 391); NW, participants that perceive themselves to be normal weight (n = 299); OW, participants that perceive themselves to be overweight or obese (n = 92). * P < 0.001; ** P < 0.05.