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Fruit and vegetable intakes, associated characteristics and perceptions of current and future availability in Dutch university students

Nicole van den Bogerd[1,*], Jolanda Maas[2], Jacob C Seidell[1] and S Coosje Dijkstra[1]
[1]Department of Health Sciences, Faculty of Science, Vrije Universiteit Amsterdam, Amsterdam Public Health Research Institute, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands: [2]Department of Neuro, Clinical & Developmental Psychology, Faculty of Behavioural and Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam Public Health Research Institute, Amsterdam, The Netherlands

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Abstract

Objective: To investigate fruit and vegetable (F&V) intakes of university students and associated demographic and lifestyle characteristics, and students' perceptions of F&V availability and F&V intervention strategies in the university environment.
Design: Cross-sectional questionnaire data were collected; F&V intakes were measured using a food frequency tool. Multivariable linear regression analyses were used to analyse the associations between demographic and lifestyle characteristics and F&V intakes.
Setting: Universities in the Netherlands.
Subjects: University students (*n* 717).
Results: The majority of students did not adhere to Dutch F&V guidelines (71 % and 93 %, respectively). Fruit intake was lower among students who were male, living independently, enrolled in a technical study, not adhering to physical activity guidelines, and heavy to excessive alcohol drinkers. Vegetable intake was lower among students who were non-Dutch, living with their parents, not adhering to physical activity guidelines, and moderate and heavy to excessive alcohol drinkers. Most students perceived that their university environment offers sufficient healthy foods (60 %) and F&V (65 %), but also indicated that their F&V intakes would increase with interventions concerning affordable F&V in the university canteen (64 %) or university supermarket (60 %). Students were less disposed to indicate that weekly local farmers' markets, vegetable parcels or a vegetable garden would increase their F&V intakes.
Conclusions: Dutch university students do not consume enough F&V. Future efforts that aim to promote students' F&V intakes should consider the differences between subgroups based on demographic and lifestyle characteristics and that affordable F&V in the university environment might be an effective strategy.

Keywords
Healthy diet
Student
University
Nutrition intervention
Fruit and vegetable intake

It is generally recognized that fruit and vegetables (F&V) form a part of a healthy diet. High daily F&V intakes are associated with reduced risk of becoming overweight and contracting diet-related chronic diseases, such as hypertension, CHD, type 2 diabetes and some types of cancer[1]. Given these beneficial effects, continued efforts are made to promote F&V intakes. However, these efforts rarely target students aged between 18 and 25 years. This is unfortunate because F&V intakes of students are far below recommendations[2–6]. The Dutch Nutrition Center recommends to eat two portions of fruit (200 g) and 250 g of vegetables daily[7], but only 9 % of the Dutch population aged 19–50 years meets the fruit guideline and only 11 % meets the vegetable guideline[8]. Students' dietary behaviours, such as low F&V intakes, are likely to continue throughout adult life[9,10]. Promoting students' F&V intakes might thus decrease their risk of becoming overweight and contracting diet-related chronic diseases during their adult life.

Insights into the determinants of students' F&V intakes could inform future F&V interventions to improve students' consumption. Previous studies have shown that

*Corresponding author: Email n.vanden.bogerd@vu.nl

students of Caucasian or Asian ethnicity, who are older, living with their parents or in houses where food is provided (e.g. campus housing) consume more F&V[3,5,6,11,12]. In addition to these demographic characteristics, F&V intakes are also associated with lifestyle characteristics. Students who are more physically active, do not smoke, sleep more hours and drink less alcohol consume more F&V[3,5,12]. These previous studies included samples of college and university students from various countries[3,5,11,12]. As far as we know, these associations have not been studied in a Dutch university student sample.

Next to demographic and lifestyle characteristics, it is well established that the physical food environment plays a key role in dietary behaviours[13]. As university students spend a lot of time in and around their university environment[14], this is an optimal environment for F&V interventions[15]. An effective F&V intervention strategy might be to enhance the availability of F&V[13,16,17], which could be done in many ways. Strategies that have received scant attention, but which might improve students' consumption levels, are the presence of farmers' markets, vegetable parcels or vegetable gardens[18,19]. Before developing F&V interventions suitable for the university environment, it is valuable first to investigate students' perceptions of F&V availability and how they perceive the effectiveness of various F&V interventions in the university environment. This optimizes interventions by tailoring them to students' needs, which may reinforce the effectiveness of the intervention.

The present study set out to investigate: (i) the F&V intakes of Dutch university students and (ii) the associated demographic and lifestyle characteristics; (iii) students' perceptions of F&V availability in the current university environment; and (iv) students' perceptions of F&V intervention strategies in the university environment. Results from the present study can guide the development of interventions to promote university students' F&V intakes.

Materials and methods

The current cross-sectional study was part of the Green Healthy Student Research Programme, which is designed to create green and healthy study environments for students in the Netherlands[20]. The Medical Ethical Committee of the Vrije Universiteit (VU) Medical Center Amsterdam, the Netherlands, approved the study protocol. Participation was voluntary and all participants provided active informed consent.

Participants

In February and March 2016, self-reported data were collected by means of an online questionnaire and an identical paper version. Both versions were available in Dutch and English. The researchers contacted the communication divisions of all thirteen (public) universities in the Netherlands to ask if they were willing to distribute an online questionnaire among their students. Eight universities were willing to participate and distributed the online questionnaire via a recruitment text with an Internet hyperlink on their student webpage. These universities included: VU University, Erasmus University Rotterdam, Eindhoven University of Technology, Leiden University, University of Amsterdam, University of Twente, Radboud University of Nijmegen, and Wageningen University and Research (WUR). Student unions of these eight universities were also asked to spread the recruitment text with the Internet hyperlink via their social media accounts. These eight universities vary in academic fields and in locations. All included universities are located in urban areas in the Netherlands, of which four are situated in the conurbation of cities in the western part of the country (Randstad). Generally, there is good access to healthy foods in the Netherlands[21]; hence, the availability of F&V between the areas where students live or where the universities are located probably does not differ a lot. Some Dutch universities have campuses offering multiple amenities such as sports facilities, bars and supermarkets. However, some inner-city universities do not have a campus and the amenities on-site are limited, but every university offers at least canteen facilities where healthy foods are available. It is not common for Dutch universities to offer student housing on campus. To increase the number of participants, a researcher (N.v.d.B.) and four students visited six of the eight participating universities to distribute the paper version of the questionnaire among students at the university canteens and restaurants.

Inclusion criteria were the ability to understand the Dutch or English language and enrolment in a Dutch research university programme. Students of applied sciences were not included in the present study. In total, 1069 students accessed the questionnaire of whom 70 % (n 749) completed the questionnaire. A total of thirty-two students were excluded because they were not enrolled at one of the eight participating universities (n 23), were a PhD candidate or an applied sciences student (n 4) or had missing values on both fruit intake as well as vegetable intake (n 5), leaving 717 students in the analyses.

Questionnaire

The questionnaire consisted of four clusters: (i) background information; (ii) evaluation of the university environment and perception of intervention strategies; (iii) evaluation of greenery in the university environment; and (iv) lifestyle information (see online supplementary material). For the purposes of the present study, data from clusters (i), (ii) and (iv) were used.

Fruit and vegetable intakes

F&V intakes were measured using a food frequency tool, which is also used in the Dutch Health Monitor[22]. This

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tool provides a reasonably accurate representation of F&V intakes[22–24]. To measure fruit intake, students indicated how many days per week they usually consume fruit on an eight-point scale ranging from 0 (less than once per week) to 7 (seven days per week). Students then indicated the number of portions they usually consume on the days that they consume fruit on a seven-point scale ranging from 0 (less than one portion) to 6 (more than five portions). A portion of fruit was illustrated as a medium-sized apple, two tangerines or a handful of small fruit such as cherries or grapes. To measure vegetable intake, students indicated how many days per week they usually consume vegetables. A definition was given: 'Examples are vegetable side dishes or salads. Vegetables as part of a large dish that also contains non-vegetable ingredients also count. Lettuce on a sandwich, however, does not'. In accordance with the guidelines of the Dutch Nutrition Center[7], we did not count potatoes as a vegetable. Students then indicated the number of serving spoons of 50 g they usually consume on the days that they eat vegetables on a seven-point scale ranging from 0 (less than one serving) to 6 (more than five servings). Fruit intake (portions/d) and vegetable intake (g/d) were calculated by multiplying the days of intake by the number of portions or serving spoons of 50 g/d, divided by 7. The Dutch Nutrition Center recommends to eat two pieces of fruit and 250 g of vegetables daily[7]. Adherence (yes/no) to the Dutch F&V guidelines was calculated.

Demographic characteristics

Demographic characteristics were assessed by items from the Dutch Student Monitor Questionnaire[25] and included: gender (female or male); age (22 years and older or younger than 22 years); ethnicity (Dutch or non-Dutch); current study discipline; and housing situation. Study discipline was assessed by an open-ended question and then categorized into: health-related studies such as medicine and biomedical science; humanities and social science studies; economics and law studies; and technical studies such as architecture, engineering and biology. Housing situation was established by asking: 'What is your housing situation?' The answer possibilities were: 'I live in a shared household', 'I live independently' and 'I live with my parents/guardians'.

Lifestyle characteristics

Based on the literature[3,5,12], six lifestyle characteristics were identified as potential characteristics associated with F&V intakes: physical activity; smoking ('Do you smoke?' yes/no); alcohol intake; stress; sleep duration; and BMI. Physical activity was assessed by two items: students first indicated the number of days per week they were physically active at a moderate intensity such as brisk walking or cycling for at least 30 min/d. Second, students indicated the number of days they were physically active at vigorous intensity such as playing soccer, tennis or exercising at the gym for at least 20 min/d. Adherence (yes/no) to the Dutch physical activity guidelines was achieved in the case of 30 min of moderate physical activity during a minimum of five days per week, or 20 min of physical activity at a heavily intense level during a minimum of three days per week[26].

To measure alcohol intake, students indicated how many days per week they usually consume alcohol and how many glasses they then usually consume on a seven-point scale ranging from 0 (less than one) to 6 (six or more glasses). In accordance with definitions given by Statistics Netherlands[27], alcohol intake was then categorized as none, moderate (<21 glasses/week for males and <14 glasses/week for females) and heavy to excessive. Alcohol intake was considered heavy to excessive if it exceeded moderate consumption or if females consumed four glasses and males consumed six glasses or more at least once per week[27].

Stress was assessed by two items[28]. Students indicated the amount of stress they usually experience on a five-point scale ranging from 0 (no stress) to 4 (extreme stress), and how well they can cope with stress on a five-point scale ranging from 0 (excellently) to 4 (very poorly)[28]. An average score (Cronbach's $\alpha = 0{\cdot}7$) was created and then dichotomized around the mean, with scores of 2 and higher reflecting high stress.

Sleep duration was calculated using four items that assessed the time students usually go to bed and wake up on weekdays and during the weekend. Based on recent recommendations, sleep duration was categorized as inadequate (less than 7 h per night), adequate (7 to 9 h per night) and excessive (more than 9 h per night)[29]. Because only twenty-nine students slept for less than 7 h per night, this subgroup was not included in the analyses.

BMI was calculated by taking students' self-reported weight in kilograms and dividing it by the square of their self-reported height in metres. BMI was categorized as healthy weight (18·5–24·99 kg/m^2), underweight (<18·5 kg/m^2) and overweight or obese (≥25·0 kg/m^2)[30].

Fruits and vegetables in the university environment and intervention strategies

Perceptions towards the availability of F&V in the university environment were assessed by asking students if they agreed with two statements: (i) 'There are sufficient healthy foods available in the university environment'; and (ii) 'There are sufficient fruits and vegetables available in the university environment'. Answer possibilities ranged on a five-point Likert scale from 0 (strongly disagree) to 4 (strongly agree).

Students' perceptions of the effectiveness of various intervention strategies of increasing their F&V intakes were assessed by asking: 'Would you eat more fruits and vegetables if you had access to the following facilities in your university environment (no or yes)? Five possible intervention strategies were asked based on literature[16,18,19]: (i) affordable F&V in the university canteen; (ii) affordable

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F&V in the university supermarket; (iii) a weekly local farmers' market; (iv) vegetable parcels that can be picked up at the university; and (v) a university vegetable garden.

Statistical analyses

Descriptive statistics are presented as numbers with percentages for categorical variables and as means with standard deviations for continues variables. Univariate and multivariable linear regression analyses were used to analyse the association between demographic and lifestyle characteristic and F&V intakes. The final multivariable models were established through a backwards selection procedure. This selection procedure is preferred over a forward selection procedure because it is less likely to make a type II error[31]. Characteristics were excluded from the multivariable model if the *P* value was higher than 0·10. Assumptions were checked, including normal distributions of the outcome variables, linearity and collinearity. Collinearity of the saturated and final multivariable linear regression models was checked with collinearity statistics; in all models, variance inflation factor values were below the threshold of 10 and all tolerance statistics were above 0·1, indicating little likelihood of biased data due to collinearity[31]. The R^2 statistic represents the model fit. Effect sizes are presented as regression coefficients (β) with 95 % confidence intervals. All analyses were performed with the statistical software package IBM SPSS Statistics version 23, and $P < 0{\cdot}05$ was considered to identify statistical significance.

Results

Sample characteristics

The study sample comprised 717 students of whom 459 were female (Table 1). Half of the sample (50 %) was younger than 22 years, the greater part of students were of Dutch ethnicity (72 %) and about a third lived with their parents or guardians (31 %). A large percentage of students adhered to the physical activity guidelines (64 %), did not smoke (78 %) and reported high levels of stress (63 %).

About half of the sample (*n* 368, 51 %) filled out the online questionnaire. Univariate regression analyses showed no statistically significant difference between the paper version and the online questionnaire for fruit intake and vegetable intake. Of the total sample, 28·6 % studied at the VU University, 20·5 % studied at Erasmus University Rotterdam, 18·4 % studied at Eindhoven University of Technology, 11·0 % studied at Leiden University, 9·1 % studied at the University of Amsterdam, 7·5 % studied at the University of Twente, 3·3 % studied at Radboud University Nijmegen and 1·5 % studied at WUR.

Fruit intake

Fruit intake ranged from 0 to 4 portions/d with a mean intake of 1·37 (SD 1·00) portions/d. Adherence to the fruit guideline was met by 27·9 % of the students (Table 2). Univariate linear regression analyses showed a statistically significant association between students' fruit intake and gender, age, ethnicity, housing situation, study discipline, physical activity and alcohol consumption (Table 3). All characteristics were included in the saturated multivariable linear regression model for fruit intake (results not shown). The model fit of this saturated multivariable model was $R^2 = 0{\cdot}12$. The final multivariable linear regression model included eight variables: gender, age, ethnicity, housing situation, study discipline, physical activity, alcohol consumption and smoking (Table 3). Adjusted for all the variables in the final model, fruit intake was statistically significantly lower among students who were male, living independently compared with those living in a shared household, enrolled in a technical study compared with students following a health-related study, not adhering to the physical activity guidelines, and heavy to excessive alcohol drinkers compared with students who do not

Table 1 Characteristics of the study population: Dutch university students (*n* 717) from eight (public) universities in the Netherlands, February–March 2016

	n	%
Gender		
Female	459	63·7
Male	257	36·1
Age		
22 years and older	358	49·9
Younger than 22 years	356	50·1
Ethnicity		
Dutch	516	72·0
Non-Dutch	200	27·9
Housing situation		
Living in a shared household	337	47·5
Living independently	152	21·2
Living with parents or guardians	222	31·0
Study discipline		
Health-related	152	21·2
Humanities and social sciences	229	31·9
Economics and law	192	26·8
Technical	138	19·2
Adherence to physical activity guideline		
Yes	464	64·7
No	251	35·0
Smoking		
Yes	147	20·5
No	562	78·4
Alcohol intake		
None	187	26·1
Moderate	371	51·7
Heavy to excessive	154	21·5
Stress		
Low stress	266	37·1
High stress	448	62·5
Sleep duration		
Adequate (7–9 h/night)	421	58·7
Inadequate (<7 h/night)	30	4·2
Excessive (>9 h/night)	256	35·7
BMI		
Healthy weight (≤18·5–24·99 kg/m^2)	550	76·7
Underweight (<18·5 kg/m^2)	41	5·7
Overweight or obese (≥25·0 kg/m^2)	93	13·0

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Table 2 Fruit and vegetable intakes and adherence to guidelines among Dutch university students (*n* 717) from eight (public) universities in the Netherlands, February–March 2016

		Intake		Adherence to guidelines		No adherence to guidelines	
	n	Mean	SD	*n*	%	*n*	%
Fruits	711	1·37†	1·00	200	27·9	511	71·3
Vegetables	714	126·18‡	64·89	49	6·8	665	92·7

†Mean fruit intake in portions per day.
‡Mean vegetable intake in grams per day.

Table 3 Univariate linear models and the final multivariable linear model for the association between demographic and lifestyle characteristics and fruit intake (portions per day) in Dutch university students (*n* 717) from eight (public) universities in the Netherlands, February–March 2016

	Univariate model		Final multivariable model†	
	β	95 % CI	*β*	95 % CI
Gender				
Female	Ref.	–	Ref.	–
Male	−0·28**	−0·44, −0·13	−0·30**	−0·45, 0·14
Age				
22 years and older	Ref.	–	Ref.	–
Younger than 22 years	−0·18*	−0·33, −0·04	−0·15	−0·31, 0·003
Ethnicity				
Dutch	Ref.	–	Ref.	–
Non-Dutch	0·23*	0·06, 0·39	0·16	−0·10, 0·32
Housing situation				
Living in a shared household	Ref.	–	Ref.	–
Living independently	−0·14	−0·33, 0·05	−0·24*	−0·42, −0·05
Living with parents or guardians	−0·23*	−0·39, −0·06	−0·14	−0·31, 0·04
Study discipline				
Health-related	Ref.	–	Ref.	–
Humanities and social sciences	0·09	−0·11, 0·29	0·05	−0·15, 0·25
Economics and law	−0·01	−0·20, 0·22	0·05	−0·16, 0·26
Technical	−0·33*	−0·56, −0·11	−0·24*	−0·47, −0·01
Adherence to physical activity guideline				
Yes	Ref.	–	Ref.	–
No	−0·34**	−0·48, −0·18	−0·37**	−0·52, −0·22
Smoking				
Yes	Ref.	–	Ref.	–
No	−0·11	−0·30, 0·07	−0·17	−0·35, 0·02
Alcohol				
None	Ref.	–	Ref.	–
Moderate	0·05	−0·12, 0·23	−0·06	−0·23, 0·12
Heavy to excessive	−0·25*	−0·46, −0·04	−0·38**	−0·60, −0·16
Stress				
Low stress	Ref.	–		
High stress	0·03	−0·12, 0·18		
Sleep duration				
Adequate (7–9 h/night)	Ref.	–		
Excessive (>9 h/night)	−0·14	−0·30, 0·03		
BMI				
Healthy weight (≤18·5–24·99 kg/m^2)	Ref.	–		
Underweight (<18·5 kg/m^2)	0·07	−0·25, 0·39		
Overweight or obese (≥25·0 kg/m^2)	−0·02	−0·24, 0·20		

β, regression coefficient; Ref., reference group.
*$P<0·05$, **$P<0·001$.
†Shows the regression coefficients of the variables included in the final model.

drink alcohol. The model fit of the final multivariable model was $R^2 = 0·11$.

Vegetable intake

Vegetable intake ranged from 0 to 300 g/d with a mean intake of 126·18 (SD 64·89) g/d. Adherence to the vegetable guideline was met by 6·8 % of the students (Table 2). Univariate linear regression analyses showed a statistically significant association between students' vegetable intake and ethnicity, housing situation and physical activity (Table 4). All characteristics were included in the saturated multivariable linear regression model for vegetable intake (results not shown). The model fit of

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Table 4 Univariate linear models and the final multivariable linear model for the association between demographic and lifestyle characteristics and vegetable intake (grams per day) in Dutch university students (*n* 717) from eight (public) universities in the Netherlands, February–March 2016

	Univariate model		Final multivariable model†	
	β	95 % CI	*β*	95 % CI
Gender				
Female	Ref.	–		
Male	−2·78	−12·71, 7·12		
Age				
22 years and older	Ref.	–	Ref.	–
Younger than 22 years	−9·20	−18·72, 0·32	−9·58	−20·02, 0·86
Ethnicity				
Dutch	Ref.	–	Ref.	–
Non-Dutch	−12·42*	−23·00, −1·83	−14·85*	−20·02, 0·86
Housing situation				
Living in a shared household	Ref.	–	Ref.	–
Living independently	−2·73	−15·17, 9·72	−3·99	−16·76, 8·79
Living with parents or guardians	−13·56*	−24·58, −2·54	−13·76*	−25·38, −2·14
Study discipline				
Health related	Ref.	–	Ref.	–
Humanities and social sciences	−11·91	−25·21, 1·40	−10·51	−23·87, 2·84
Economics and law	−15·32*	−29·11, −1·52	−11·66	−25·50, 2·18
Technical	−14·93*	−29·86, −0·01	−13·66	−28·56, 1·25
Adherence to physical activity guideline				
Yes	Ref.	–	Ref.	–
No	−19·76**	−29·66, −9·85	−18·32**	−28·32, −8·32
Smoking				
Yes	Ref.	–		
No	−0·11	−0·29, 0·07		
Alcohol				
None	Ref.	–	Ref.	–
Moderate	−4·61	−16·04, 6·83	−12·75*	−24·52, −0·97
Heavy to excessive	−7·53	−21·41, 6·36	−17·53*	−31·98, −3·06
Stress				
Low stress	Ref.	–		
High stress	−0·59	−10·45, 9·29		
Sleep duration				
Adequate (7–9 h/night)	Ref.	–		
Excessive (>9 h/night)	−1·19	−12·26, 9·91		
BMI				
Healthy weight (≤18·5–24·99 kg/m^2)	Ref.	–		
Underweight (<18·5 kg/m^2)	11·32	−9·18, 31·82		
Overweight or obese (≥25·0 kg/m^2)	−4·07	−19·27, 10·13		

β, regression coefficient; Ref., reference group.
*$P<0·05$, **$P<0·001$.
†Shows the regression coefficients of the variables included in the final model.

this saturated multivariable model was $R^2=0·06$. The final multivariable linear regression model included six variables: age, ethnicity, housing situation, study discipline, physical activity and alcohol consumption (Table 4). Adjusted for all the variables in the final model, vegetable intake was statistically significantly lower for students who were non-Dutch, living with their parents compared with those living in a shared household, not adhering to physical activity guidelines, and moderate alcohol drinkers and heavy to excessive alcohol drinkers compared with students who do not drink alcohol. The model fit of the final multivariable model was $R^2=0·05$.

Fruits and vegetables in the university environment

Table 5 shows that most students agreed or strongly agreed with the statements that their university environment offered sufficient healthy foods (60 %) and sufficient F&V (65 %). About 64 % indicated that they would consume more F&V if they had access to a university canteen with affordable F&V, and 60 % if they had access to a university supermarket with affordable F&V. Less than half of the students indicated that they would consume more F&V if the university environment offered a weekly local farmers' market (44 %), vegetable parcels that could be picked up at the university (40 %) or a vegetable garden (29 %).

Discussion

The current cross-sectional study was designed to provide insights into F&V intakes in Dutch university students. First, the study showed that F&V intakes were low and the

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Table 5 Perceptions towards the availability of healthy foods and fruits and vegetables (F&V) in their university environment and five intervention strategies aiming to increase their F&V intakes among Dutch university students (*n* 717) from eight (public) universities in the Netherlands, February–March 2016

	n	%
There are sufficient healthy foods available in the university environment		
Strongly disagree	18	2·5
Disagree	114	15·9
Neutral	148	20·6
Agree	333	46·5
Strongly agree	100	13·9
There are sufficient F&V available in the university environment		
Strongly disagree	11	1·5
Disagree	76	10·6
Neutral	159	22·2
Agree	362	50·5
Strongly agree	104	14·5
Would consume more F&V if the university environment offered		
University canteen with affordable F&V	457	63·7
University supermarket with affordable F&V	432	60·3
Weekly local farmers' market	316	44·1
Vegetable parcels	289	40·3
A vegetable garden	207	28·9

vast majority of students did not adhere to Dutch F&V guidelines. Second, it identified risk groups for low F&V intakes based on demographic and lifestyle characteristics. Third, it showed that a large proportion of students perceived that there are sufficient healthy foods and F&V available in their university environment. Fourth, it showed that most students expected that affordable F&V in the university canteen or university supermarket would increase their F&V intakes.

The results of the current study showed that students' mean F&V intakes were far below the recommendations, with only 28 % consuming at least two portions of fruit and 7 % consuming at least 250 g of vegetables daily. Although guideline adherence rates found in other student populations are based on five servings of F&V per day, they are comparable with the low adherence rates found in our study. For example, F&V recommendations are met by only 5 % of first-year German university students[2], 16 % of Saudi Arabian university students[3] and 34 % of university college students from the UK[4]. This suggests that low F&V intakes among students are a widespread problem, and more efforts are needed to increase F&V intakes of students. It should be noted that our study sample was relatively healthy compared with the Dutch population. We found a higher adherence rate to the fruit guideline (28 % *v.* 9 %) than in the general Dutch population aged 19–50 years and a comparable adherence rate to the vegetable guideline (7 % *v.* 11 %)[8]. Our sample also had a higher a adherence rate to the physical activity guideline (65 % *v.* 57 %), and included more smokers (78 % *v.* 71 %) and students with a healthy BMI (71 % *v.* 67 %) compared with the Dutch population of the same age[27]. An explanation for this might be that university students are more highly educated than the general Dutch population as a whole and therefore adapt healthier lifestyle choices[32].

An essential aspect of the present study is the identification of several risk groups for low F&V intakes. Multivariable linear regression analyses showed that fruit intake was lower among students who were male, living independently, enrolled in a technical study, not adhering to the physical activity guidelines, and heavy to excessive alcohol drinkers. Vegetable intake was lower among students who were non-Dutch, living with their parents or guardians, not adhering to the physical activity guidelines, and moderate and heavy to excessive alcohol drinkers. Some of these associations are consistent with previous studies, which showed that non-European students who are more physically active[3,5,12] and drink less alcohol[5,12] consume more F&V. Although in the current study the associations between a younger age and low F&V intakes were not statistically significant, studies in non-European low-, middle- and high-income countries have shown lower F&V intakes in younger students[5,6]. Contrary to other studies, the current study results imply that, in the Netherlands, living in shared housing has a beneficial influence on students' F&V intake. Studies among students from Asia, Africa and South America have suggested that living with parents or family has a positive influence on students' F&V intakes[3,5]. Consistent with these studies, European students who live with their parents reported healthier dietary behaviours than students who do not[33]. This discrepancy may be explained by the fact that living in shared student housing in the Netherlands also involves shared grocery shopping, cooking with F&V and eating together. Students who live independently might have insufficient resources to purchase fruits, and students who live with their parents or guardians might not be involved or have little influence on the vegetable groceries or the content of the family meals. However, future research should investigate these differences in more detail, for example by performing focus group discussions with students from different housing situations to discuss underlying mechanisms. Furthermore, the results of our study suggest that there are differences in F&V intakes between subgroups based on study discipline. In particular, students from a technical study reported lower F&V consumption than students from a health-related study. It is not surprising that those with an interest in and knowledge of health and the determinants influencing health are more prone to make healthier food choices. Yet, this finding may suggest that students enrolled in a technical study need additional support.

Most students reported that their university environment offers sufficient healthy foods and F&V. Nevertheless, students expected that F&V interventions in the university environment could encourage their F&V intakes. The most popular proposed intervention strategies were offering

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affordable F&V in the university canteen and university supermarket. Similar results were found in a Dutch study which reported that students aged between 13 and 15 years expected that free fruit at school would stimulate healthy dietary behaviours[34]. Moreover, Australian university students reported that they would like an increased availability of fresh fruit on the university campus[35]. With the availability of affordable F&V, the university environment can play a pivotal role in encouraging students' F&V intakes. Increased availability of healthy foods has been shown to be effective in promoting healthy dietary behaviours[16,36] and offering F&V that are affordable or lowering the price of F&V in the university environment could be effective in increasing intakes[37]. However, more research is needed to establish what kind of price promotions on F&V are required to increase students' F&V intakes and to find out what the effects are of F&V interventions in the university environment on students' intakes.

The present study has several strengths. To the best of our knowledge, it is the first study that has investigated demographic and lifestyle characteristics associated with F&V intakes and, although explorative, perceptions of F&V interventions in Dutch university students. Not only did the findings extend the current knowledge, they appear relevant. Between some subgroups, fruit intake differed by 0·5 portions/d and vegetable intake differed by 30 g/d. Moreover, fruit intake and vegetable intake were not associated with the same characteristics, which can be valuable information for health promoters because it might demonstrate that promoting fruit intake requires a different approach from promoting vegetable intake.

Limitations should be noted as well. Selection bias might have led to reduced generalizability because the response rate was low and not all thirteen Dutch public universities participated. Response bias, such as social desirability, is common in self-reported questionnaires, and might have led to underestimations or overestimations of the present associations. Nevertheless, F&V intakes were measured with a validated short FFQ[22–24] that accurately identifies the F&V intakes in samples comparable to the student sample[38,39]. Additionally, the R^2 of the multivariable regression models were low, indicating a large proportion of unexplained variance[40]. This implies that other factors such as individual factors (e.g. personal barriers) or environmental factors (e.g. costs) also play a role in influencing students' F&V intakes. We therefore recommend that future studies into determinants influencing students' F&V intakes not only include demographic and lifestyle factors, but also environmental and individual factors.

Conclusion

In conclusion, given that the vast majority of Dutch university students did not meet the F&V guidelines, more efforts are needed to promote their F&V consumption. When promoting F&V intakes in students, health promoters should consider that F&V intakes differ between subgroups based on demographic and lifestyle characteristics; and, moreover, they should consider that fruit intake is associated with other factors than vegetable intake. Affordable and accessible F&V in the university environment could potentially increase students' F&V intakes. Nevertheless, more research is needed to establish the effectiveness of such strategies. The findings of the present study could guide the design of interventions that aim to increase students' F&V intakes.

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Supplementary material

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