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Direct and indirect association between environmental factors and fruit intake, mediation by psychosocial factors: the Pro Children study

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Abstract

Objectives: To explore direct associations between home and school availability of fruit and fruit intake, and the mediating role of attitude towards fruit, liking, perceived barriers and self-efficacy.
Design: Cross-sectional study.
Setting: Primary schools in nine European countries.
Subjects: Within the Pro Children study, data were collected on perceived home and school availability of fruit, psychosocial factors related to fruit intake and its frequency among 13 305 11-year-old schoolchildren.
Results: Significant overall associations were found between child-reported home availability of fruit and fruit intake in all countries and in the total sample. School availability of fruit was associated with fruit intake in the pooled sample and in country-specific analyses in Sweden and the Netherlands. Liking (13·2–49·4 %) and self-efficacy (14·0–25·1 %) were the strongest mediators in the home availability–fruit intake relationship, but there was also a direct association between home availability and fruit intake, except in Spain and the Netherlands. Mediating pathways of the school availability–fruit intake relationship could only be assessed for Norway, Sweden and the total sample. Attitude was a significant mediator in Norway (80·4 %) and in Sweden (25·3 %), while in the total sample also liking (38·7 %) and self-efficacy (23·0 %) were identified as significant mediators.
Conclusions: The association between home availability of fruit and fruit intake is at least partly mediated by personal factors such as liking and self-efficacy indicates that fruit intake is not a complete automatic or unconscious behaviour.

Keywords
Environment
Fruit intake
Mediation
Psychosocial factors

Several studies have shown that fruit and vegetable intake among European children and adolescents is lower than the international daily recommended intake levels[1,2]. Moreover, intake is declining among American adolescents[3] and in some European countries[4], although a positive trend was found among English children between 2000 and 2005[5]. Regular intake of fruit and vegetables has been associated with lower risk of CVD, including obesity, hypertension and type 2 diabetes mellitus and some cancers[6–8]. On the other hand, a recent paper by Newby[9] reported that there is no support for the proposition that any plant food intake is inversely correlated with adiposity among children. However, Newby also stated that the lack of evidence showing an association between plant-based diets and childhood obesity does not mean that such diets should not be encouraged. Plant foods are considered to be part of a healthy balanced diet, which in combination with physical activity, is recommended as important in weight management and prevention of unnecessary weight gain[10]. Promoting fruit intake is considered a goal for the promotion of population health, especially among children and adolescents, since some studies have shown that fruit intake might track into adulthood[11–13], and that preferences established early in life tend to be maintained during adulthood as well[14]. In order to promote children's intake of fruit and vegetables, insight into important mediating factors is necessary[15,16]. Mediating factors or mediators are variables that explain the association between the two variables or are in the pathway between two the variables.

Previous studies have shown associations between the reported intake of fruit and vegetables and environmental

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and psychosocial factors, including availability[17,18], preferences for fruit, knowledge of the daily recommended intake levels, behavioural capability (skills) in determining healthy choices, outcome expectations[18], self-efficacy[18,19], preferences for fruit and vegetables[17] and perceived parental influences[19]. Kratt *et al.*[18] and Young *et al.*[19] showed that the association between psychosocial factors and intake was moderated by availability, i.e. this association changed as the level of availability changed. Cullen *et al.*[17] suggested that preferences moderate the association between availability and intake. Based on these studies and a study by Jago *et al.*,[20] we could say that the exact mechanisms between availability and intake and the nature of this relationship with psychosocial factors are still unclear and that, to our knowledge, no other studies have explored the potential pathways in fruit availability at home or school and fruit intake relationship. The role of the environment is getting more attention in the social–ecological models[21], and more research is needed regarding 'how' environments might affect behaviour[22,23]. The EnRG framework postulates that the environment influences behaviour both directly and indirectly[23]. Since children and adolescents may have less autonomy in making healthy dietary choices, environmental influences can have a direct influence on their intake. Such a direct influence reflects the automatic, unconscious influence of the environment on behaviour[24]. The indirect causal mechanism reflects the mediating role of behaviour-specific cognitions in the influence of the environment on behaviour[23]. Furthermore, the association between environmental factors and behaviour might differ by geographical and psychosocial factors. Within the European Pro Children study, data on intake of fruit and environmental and psychosocial factors have been collected among 13 305 children from nine European countries. Therefore, the current study provided the opportunity to study potential mediating pathways between fruit availability at home and school and fruit intake. Results will contribute to unravelling the still unclear nature of the fruit availability–fruit intake relationship. In addition, the data also provided the opportunity to explore whether the same potential mediators are important across the nine countries. Therefore, the aim of the present study was to explore the associations between home and school availability of fruit and fruit intake, and the potential mediating role of four psychosocial factors in nine European countries.

Method

Design and sample

The study used data from the European Pro Children cross-sectional study on children's fruit and vegetable intake and potential environmental and psychosocial determinants[25]. The cross-sectional study involved nine European countries (Austria, Belgium, Denmark, Iceland, the Netherlands, Norway, Portugal, Spain and Sweden). Data were collected during October–December 2003 involving national representative samples of schools in all countries with the exception of Austria (for Austria, the sample was representative for the Eastern region) and Belgium (for Belgium, the sample was representative for Flanders). Schools were used as the sampling unit, and from each country at least twenty schools were sampled and a minimum of 1300 eligible children were included. Participation rates ranged from 70 % to 97 %, with Portugal (45 %) and the Netherlands (30 %) showing lower participation rates. The most frequent reason for schools not participating in the study were time constraints. Participating students completed a questionnaire in the classroom. Reasons for non-participation at the pupil level were not being present at the time of data collection, and were thus not related to specific reasons related to the project. Ethical approval was obtained from all relevant ethics committees in all countries before participation. Eleven-year-old children were recruited to the study, and a response rate of 90·4 % was reached in the participating schools; response rates ranged from 79·7 % to 98·4 %, with Portugal showing the highest rates and the Netherlands showing the lowest response rates. Mean age was 11·4 years (range: 8·8–13·8, SD = 0·48; 79 % of the children were born in 1992), and 50·2 % were boys. The final sample sizes varied from 1105 for the Netherlands to 2134 for Portugal, with a total sample size of 13 305 students. A more detailed description of the Pro Children project, including the sampling and data collection procedure, is given elsewhere[1,25]. Owing to missing values, a maximum of 12 200 children (91·7 %) were included in the analyses. Children were only included in the analyses when they had complete data on the predictor variable, the mediators as well as the outcome variable. Boys were more likely to have at least one missing variable (OR = 1·49, 95 % CI 1·29, 2·09).

Measures

A self-reported questionnaire was developed to measure fruit and vegetable intake, and the related environmental and psychosocial factors. The development of the questionnaire was based on theoretical models[25], a literature review[26], focus group interviews with children[27], individual interviews with parents and school staff and thorough pre-testing[28,29]. Fruit intake was assessed by an FFQ: 'How often do you usually eat fresh fruit', with an 8-point answer scale ranging from never (0) to every day more than twice a day (7). A separate validation study showed reasonable-to-good test–retest reliability (Spearman r from 0·47 to 0·77) and, in general, adequate validity comparing the food frequency questions with 7 d food records (Spearman r from 0·43 to 0·51)[28]. As part of the demographics questionnaire, gender and age (calculated based on the year and month of birth) were included in the present study.

Perceived availability of fruit at home and at school was assessed using a bipolar 5-point scale ranging from 'yes always' to 'never'. All four psychosocial factors (i.e. attitudes

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Table 1 Constructs and items of the Pro Children questionnaire

Constructs	Cronbach's α	Items	Response categories
Fruit intake	N/A	How often do you usually eat fruit?	(0) Never, (1) <1 d/week, (2) 1 d/week, (3) 2–4 d/week, (4) 5–6 d/week, (5) every day, once a day, (6) every day, twice a day and (7) every day more than twice a day
Perceived availability at home	N/A	Are there usually different kinds of fruit available at your home?	5-point scale from 2 (yes, always) to −2 (never)
Perceived availability at school	N/A	Can you get fruit at school either by buying it or getting it or free?	5-point scale from 2 (yes, always) to −2 (never)
Attitude	0·73	Eating fruit every day makes me feel good Eating fruit every day gives me more energy	5-point scale from 2 (I fully agree) to −2 (I fully disagree)
Liking	0·68	I like to eat fruit every day Fruit tastes good	5-point scale from 2 (I fully agree) to −2 (I fully disagree)
Self-efficacy	0·39	It is difficult for me to eat fruit every day If I decide to eat fruit every day, I can do it	5-point scale from 2 (I fully agree) to −2 (I fully disagree)
Perceived barriers	0·72	I do not eat fruit because: ● It takes too much time to eat ● I want to eat something else (e.g. sweets) ● My fingers get greasy when I eat it ● It gets squeezed in the school bag	5-point scale from 2 (I fully agree) to −2 (I fully disagree)

N/A, not applicable.

towards fruit, liking of fruit, self-efficacy for eating fruit and barriers to prevent eating fruit) were assessed using a bipolar 5-point scale ranging from 'fully agree' to 'fully disagree'. Before the analyses, composite scores were calculated for these four factors as the mean of two or four items. Intra-class correlations in the test–retest reliability analyses of these factors were 0·58–0·74, while Cronbach α values ranged from 0·42 for self-efficacy, 0·53 for perceived barriers, 0·61 for attitude to 0·70 for liking, respectively (see De Bourdeaudhuij *et al.*[29] for detailed information on the psychometrics and also see Table 1 for a more detailed description of the measures).

Analyses

A series of multiple regression analyses were performed to identify mediation of the association between fruit availability and fruit intake by the individual-level psychosocial factors: attitude, liking, barriers and self-efficacy. Basically, suggestions from MacKinnon[30] were followed. First, the overall effect (path c) of the predictor variable (*X*, fruit availability) on the outcome variable fruit intake (*Y*) was assessed (see Fig. 1). Subsequently, associations between fruit availability (*X*) and the mediators (M_i) (paths a) were assessed. Then, associations between the mediators (M_i) and the outcome variable fruit intake (*Y*) were assessed (paths b) in a multiple regression model that was adjusted for the predictor variable (*X*). Those mediators that were significantly associated with both the predictor variable and the outcome variable were selected for the final multiple mediation model. The 'mediated effect' was calculated following the 'product-of-coefficients' method[30], i.e. by multiplying the α-coefficient by the β-coefficient. The β-coefficients

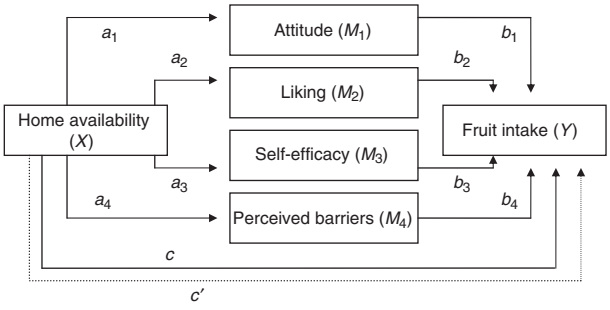

Fig. 1 The mediation model for the association between availability and fruit intake. X, predictor variable; *Y*, outcome variable; M_1, mediator variable; a_i, association between predictor variable (*X*) and potential mediator (M_1); b_i association between predictor variable (*X*) and outcome variable (*Y*); *c*′, direct effect (unnamed) of predictor variable (*X*) on outcome variable (*Y*)

were derived from the final multiple mediation model including only the selected mediators. Standard errors for the mediated effect were calculated as:

$$\mathrm{SE}_{a\times b} = \sqrt{(a^2 \times \mathrm{SE}b^2 + b^2 \times \mathrm{SE}a^2)} \qquad \text{Equation (1)}$$

In case more than one mediator was significantly associated with both the predictor variable and the outcome variable, total mediated effect by two or more mediator variables was calculated by summing the mediated effects of the individual mediators derived from a multiple regression equation ($\sum(a_i \times b_i)$). Standard errors for the total mediated effects were calculated according to the following equation:

$$\mathrm{SE}_{\Sigma a_i \times b_i} = \sqrt{(a_1^2 \times \mathrm{SE}b_1^2 + b_1^2 \times \mathrm{SE}a_1^2 + a_2^2 \times \mathrm{SE}b_2^2 + b_2^2 \times \mathrm{SE}a_2^2 + \ldots + 2 \times a_1 \times a_2 \times \mathrm{COV}_{b_1 b_2} + \ldots)} \qquad \text{Equation (2)}$$

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Table 2 Total effects (path c) of fruit availability at home and school on fruit intake for all nine countries and the total sample

	Total effect*					
	Home availability			School availability		
Country	*n*	OR	95 % CI	*n*	OR	95 % CI
Norway	1116	**0·285**	**0·212, 0·358**	1104	0·014	−0·023, 0·052
Spain	1268	**0·281**	**0·203, 0·359**	1271	0·014	−0·023, 0·050
Iceland	1156	**0·305**	**0·236, 0·374**	1143	0·007	−0·025, 0·039
Denmark	1809	**0·476**	**0·409, 0·543**	1822	0·022	−0·008, 0·052
Portugal	2075	**0·199**	**0·134, 0·264**	2077	0·009	−0·016, 0·035
Austria	1667	**0·324**	**0·246, 0·402**	1646	−0·001	−0·031, 0·029
The Netherlands	1085	**0·237**	**0·161, 0·313**	1071	**0·082**	**0·001, 0·162**
Sweden	1368	**0·365**	**0·292, 0·438**	1358	**0·049**	**0·013, 0·086**
Belgium	1336	**0·261**	**0·200, 0·322**	1317	0·010	−0·020, 0·041
Total	12 880	**0·307**	**0·284, 0·331**	12 809	**0·017**	**0·006, 0·028**

*Assessed by regression analyses adjusted for age and gender and the nested design.
Bold values represent significant association.

In equations 1 and 2, 'a' stands for the regression coefficient in path a, 'b' stands for the regression coefficient in path b, and the numbering reflects the different mediators. $COV_{b_1 b_2}$ stands for the covariance between the two b estimates and the $2 \times a_1 \times a_1 \times COV_{b_1 b_2}$ is repeated for all pairs of coefficients in the multiple mediator model.

The proportion of the total effect that was mediated by the mediator(s) was calculated by dividing the mediated effect by the total effect ($c' + \sum(a_i \times b_i)$ and multiplying by 100 %. This proportion was not calculated in case of a non-significant mediation effect.

A significant overall relationship between the predictor variable and the outcome variable was not a requirement to continue the mediation analyses, since absence of an overall relationship may be due to suppression effects[30,31].

In the mediation analyses, we used the term 'effect' next to 'association' to be consistent with MacKinnon's terminology, even though we realize that the analyses are cross-sectional and no conclusions can be drawn in the direction of causality. All analyses were corrected for gender and age, and conducted per country and for the total sample. Further, all analyses took into account the nested design of the study, i.e. pupils nested within schools (and within countries), by using mixed-effects REML regression analyses in the STATA/IC statistical software package version 10·1 (StataCorp LP, College Station, TX, USA). Descriptive statistics were provided in the Statistical Package for the Social Sciences statistical software package version 15·0 (SPSS Inc., Chicago, IL, USA). For associations, the significance level was set at $P < 0·05$.

Results

Associations of home and school availability with fruit intake

Significant overall associations (path c) were found for child-reported home availability of fruit with child-reported fruit intake in all countries (c varied between 0·199 and 0·476) and for the total sample (c = 0·332; 95 % CI 0·307, 0·357; see Table 2). School availability as reported by the child was significantly associated with intake in two countries (the Netherlands: c = 0·081; 95 % CI 0·001, 0·161; Sweden: c = 0·049, 95 % CI 0·014, 0·084) and in the total sample (c = 0·017; 95 % CI 0·006, 0·028).

Table 3 shows the association between home and school availability with the four potential mediators: attitude, liking, self-efficacy and barriers (path a) for the nine countries separately and for the total sample. As can be seen, home availability was significantly associated with all the four potential mediators. Positive associations were observed for home availability and attitude towards fruit intake, liking of fruit and self-efficacy for eating fruit, while higher home availability was inversely associated with perceived barriers to eating fruit.

In the total sample, school availability was significantly associated with three potential mediators: attitude towards fruit intake, liking of fruit and self-efficacy for eating fruit. School availability was positively associated with attitude towards fruit in five countries (Norway, Spain, Denmark, Austria and Sweden), while school availability was associated with liking in only two countries (Spain and Denmark). In none of the countries was school availability associated with self-efficacy, and perceived barriers were only significantly associated with school availability in Denmark.

Associations between potential mediators and fruit intake

Table 3 also shows the associations between the potential mediators and the outcome variable fruit intake (path b). In the total sample liking, self-efficacy and perceived barriers were significantly associated with fruit intake while adjusting for home availability, whereas attitude towards fruit intake was not. Nevertheless, a significant pathway between attitude and fruit intake was observed in five countries (Iceland, Denmark, Austria, the Netherlands and Belgium). In accordance with the findings in the

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Table 3 Associations between availability, and the four potential mediators, and associations between the four potential mediators and intake, for all countries and the total sample

		Association between predictor and potential mediators (path a)*				Association potential mediators and fruit intake (path b)*†			
		Home availability		School availability		Home availability		School availability	
		Estimate		Estimate		Estimate		Estimate	
	Potential mediator	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Norway	Attitude	0·235	0·161, 0·309	0·008	−0·026, 0·042	0·062	−0·002, 0·127	0·075	0·010, 0·140
	Liking	0·263	0·202, 0·324	−0·001	−0·026, 0·024	0·255	0·169, 0·341	0·269	0·183, 0·356
	Self-efficacy	0·341	0·265, 0·417	0·010	−0·024, 0·044	0·114	0·056, 0·172	0·132	0·073, 0·190
	Barriers	−0·256	−0·332, −0·180	−0·003	−0·035, 0·030	−0·037	−0·097, 0·023	0·031	−0·108, 0·013
Spain	Attitude	0·368	0·304, 0·432	0·037	0·007, 0·068	0·035	−0·036, 0·106	0·041	−0·030, 0·112
	Liking	0·506	0·431, 0·581	0·037	0·003, 0·071	0·202	0·134, 0·124	0·212	0·144, 0·280
	Self-efficacy	0·436	0·349, 0·522	0·013	−0·025, 0·051	0·156	0·098, 0·214	0·154	0·096, 0·212
	Barriers	−0·266	−0·341, −0·190	0·007	−0·027, 0·042	−0·106	−0·165, −0·046	−0·109	−0·169, −0·050
Iceland	Attitude	0·310	0·240, 0·380	0·022	−0·011, 0·055	0·110	0·044, 0·176	0·120	0·053, 0·186
	Liking	0·312	0·253, 0·371	0·027	−0·001, 0·055	0·114	0·028, 0·200	0·129	0·042, 0·216
	Self-efficacy	0·412	0·340, 0·484	0·016	−0·018, 0·049	0·169	0·110, 0·228	0·194	0·135, 0·253
	Barriers	−0·261	−0·319, −0·203	0·006	−0·021, 0·033	−0·012	−0·085, 0·062	−0·033	−0·107, 0·041
Denmark	Attitude	0·401	0·343, 0·459	0·048	0·021, 0·075	0·098	0·040, 0·156	0·116	0·059, 0·174
	Liking	0·458	0·405, 0·511	0·039	0·018, 0·061	0·201	0·129, 0·274	0·235	0·163, 0·306
	Self-efficacy	0·469	0·409, 0·530	0·051	0·028, 0·073	0·204	0·147, 0·260	0·230	0·173, 0·287
	Barriers	−0·342	−0·396, −0·289	−0·026	−0·047, −0·005	−0·041	−0·099, 0·016	−0·061	−0·118, −0·004
Portugal	Attitude	0·141	0·096, 0·185	0·009	−0·009, 0·026	−0·003	−0·067, 0·061	0·004	−0·060, 0·068
	Liking	0·246	0·200, 0·291	−0·0002	−0·017, 0·017	0·391	0·323, 0·459	0·397	0·330, 0·464
	Self-efficacy	0·252	0·191, 0·313	0·004	−0·019, 0·027	0·138	0·090, 0·186	0·143	0·095, 0·191
	Barriers	−0·212	−0·269, −0·155	−0·016	−0·039, 0·006	−0·016	−0·065, 0·034	−0·022	−0·071, 0·027
Australia	Attitude	0·342	0·276, 0·409	0·026	0·001, 0·050	0·078	0·017, 0·140	0·085	0·023, 0·147
	Liking	0·352	0·286, 0·418	0·021	−0·002, 0·043	0·224	0·154, 0·293	0·235	0·165, 0·306
	Self-efficacy	0·389	0·313, 0·464	0·009	−0·018, 0·036	0·160	0·106, 0·213	0·165	0·110, 0·219
	Barriers	−0·381	−0·449, −0·313	−0·021	−0·047, 0·005	−0·120	−0·179, −0·060	−0·135	−0·195, −0·076
The Netherlands	Attitude	0·164	0·065, 0·264	0·090	−0·004, 0·183	0·069	0·023, 0·115	0·072	0·026, 0·117
	Liking	0·391	0·304, 0·479	0·052	−0·031, 0·134	0·212	0·153, 0·270	0·214	0·156, 0·272
	Self-efficacy	0·391	0·285, 0·497	0·009	−0·092, 0·111	0·150	0·106, 0·195	0·153	0·109, 0·198
	Barriers	−0·232	−0·298, −0·165	−0·027	−0·090, 0·037	−0·069	−0·136, −0·002	−0·073	−0·140, −0·006
Sweden	Attitude	0·375	0·304, 0·447	0·043	0·009, 0·078	0·043	−0·016, 0·102	0·066	0·007, 0·126
	Liking	0·390	0·326, 0·454	0·010	−0·019, 0·039	0·247	0·174, 0·321	0·265	0·190, 0·339
	Self-efficacy	0·493	0·417, 0·570	0·015	−0·021, 0·051	0·175	0·119, 0·231	0·189	0·133, 0·245
	Barriers	−0·230	−0·288, −0·173	0·022	−0·005, 0·049	−0·009	−0·077, 0·059	−0·025	−0·093, 0·042
Belgium	Attitude	0·208	0·147, 0·269	−0·011	−0·044, 0·021	0·074	0·018, 0·129	0·077	0·020, 0·133
	Liking	0·303	0·244, 0·363	0·016	−0·011, 0·043	0·235	0·172, 0·300	0·242	0·177, 0·306
	Self-efficacy	0·396	0·324, 0·469	0·012	−0·026, 0·049	0·119	0·070, 0·168	0·130	0·081, 0·179
	Barriers	−0·285	−0·341, −0·230	−0·007	−0·035, 0·021	−0·103	−0·164, −0·043	−0·116	−0·176, −0·055
Total	Attitude	0·283	0·261, 0·305	0·023	0·014, 0·033	0·065	0·044, 0·085	0·075	0·055, 0·095
	Liking	0·353	0·333, 0·374	0·019	0·011, 0·028	0·240	0·216, 0·264	0·253	0·229, 0·277
	Self-efficacy	0·393	0·333, 0·374	0·018	0·007, 0·028	0·155	0·137, 0·173	0·165	0·147, 0·183
	Barriers	−0·276	−0·297, −0·255	−0·008	−0·017, 0·001	−0·058	−0·078, −0·038	−0·069	−0·090, −0·049

*Adjusted for each other and adjusted for predictor variable (*X*).
†Adjusted for gender and age and nested design.

total sample, significant pathways between liking and fruit intake and between self-efficacy and fruit intake were found in all nine countries. Perceived barriers for eating fruit adjusted for home availability were significantly associated with intake in four countries (Spain, Austria, the Netherlands and Belgium).

Adjusted for school availability, all four potential mediators were significantly associated with fruit intake in the total sample. In line with this, in all nine countries separately liking and self-efficacy adjusted for school availability were significantly associated with fruit intake and attitude was significantly associated with fruit intake in seven countries (but not in Norway and Spain). Perceived barriers adjusted for school availability of fruit were associated with fruit intake in five countries (Spain, Denmark, Austria, the Netherlands and Belgium).

Mediated effects, proportions mediated and direct effects

Mediation effects (product of coefficients, $a \times b$) were calculated in multiple mediator models for those mediators that showed a significant association with the predictor variable (home or school availability) and with the outcome variable adjusted for the predictor variable. Table 4 shows the results for home availability as the predictor variable and Table 5 for the findings with school availability as the predictor variable.

In the total sample attitude, liking, self-efficacy and perceived barriers were all significant mediators in the relationship between home availability of fruit and fruit intake. Liking and self-efficacy came out as the strongest mediators, explaining 27·7% and 19·9%, respectively, of the relationship. All four mediators explained 58·8% of the association, but home availability had also a direct effect on fruit intake, as shown by the significant c′ pathway ($c' = 0{\cdot}126$; 95% CI 0·0284, 0·331). Liking and self-efficacy were also the strongest mediators in all countries separately, as shown by the proportion mediated varying between 13·2% and 49·4% for liking and between 14·0% and 25·1% for self-efficacy. Attitude was a significant mediator in five countries (Iceland, Denmark, Austria, the Netherlands and Belgium) explaining between 4·9% and 11·6% of the total effect. Finally, perceived barriers were found to be a significant mediator in four countries (Spain, Austria, the Netherlands and Belgium), explaining between 6·8% and 14·1% of the total effect of home availability on fruit intake.

In most countries, home availability was also directly associated with fruit intake, as shown in the last column of Table 4. Only in Spain and the Netherlands was the relationship completely mediated by the included mediators.

Regarding the relationship between school availability and fruit intake, this association appeared to be completely mediated by the three mediators when considering the total sample. Again, liking and self-efficacy came out as the strongest mediators, explaining 38·7% and 23·0%, respectively, of the total association. There was no significant direct association of school availability with fruit intake. Regardless of an existing overall relationship between school availability of fruit and fruit intake, mediation analyses were conducted for all countries separately and the results are shown in Table 5.

In four countries, Iceland, Portugal, the Netherlands and Belgium, no mediating pathways were found and in none of the countries was a direct association of school availability of fruit with fruit intake observed. Attitude was a significant mediator in four countries (Norway, Denmark, Austria and Sweden) and liking was a significant mediator in two countries (Spain and Denmark). In addition, in Denmark self-efficacy was the strongest mediator between school availability of fruit and fruit intake. Perceived barriers appeared not to be a mediator in the relationship between school availability of fruit and fruit intake.

Discussion

Previous research showed that fruit intake of schoolchildren is associated with both environmental and psychosocial factors, indicating that interventions should be addressing both the environment and the individual[26,32]. Changing cognitions would, however, be inefficient when the relationship between availability and intake is not cognitively mediated[23]. Mediation analyses help to gain more insight into 'how' the environment may affect behaviour[15,16,22]. In the present study, we explored the complex relationship between perceived availability, i.e. a presumed important physical environmental determinant, and fruit intake of schoolchildren in Europe and the possible mediating role of individual-level factors. The present study suggests that home availability of fruit does have a direct association with fruit intake in most countries and is at least partly mediated by individual-level mediators in all countries. The observed associations were mainly mediated by liking and self-efficacy for eating fruit, indicating that fruit intake is not a completely unconscious or automatic behaviour.

Liking and self-efficacy were significant mediators in all countries, suggesting that this mediating pathway was not influenced by country differences in, e.g. socio-cultural environments and/or school environmental factors.

School availability of fruit was significantly associated with self-reported fruit intake in the total sample and in the Netherlands and Sweden. In the Dutch case, this association was not mediated by the variables included in the present study. It may be that other variables explain the association, or that fruit intake is indeed directly influenced by school availability. In Sweden, the attitude towards fruit intake could explain about 25% of the association, suggesting that a higher availability of fruit at school may positively influence attitude, which in turn influences fruit intake. From the analyses in the total

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Table 4 Mediated effects ($a \times b$), proportion mediated ($a \times b/c$) and direct effects (path c′) of fruit availability at home on fruit intake in the final model in nine European countries

		β-Coefficient in final mediation model		Mediated effect ($a \times b$)		Proportion mediated	Direct effect of home availability on fruit intake (c′)	
Country	Mediator	OR*	95 % CI	OR	95 % CI	%	OR*	95 % CI
Norway	Liking	**0·308**	**0·235, 0·381**	**0·081**	**0·054, 0·108**	**28·2**		
	Self-efficacy	**0·118**	**0·061, 0·175**	**0·040**	**0·019, 0·062**	14·0		
	Liking and self-efficacy			**0·121**	**0·091, 0·151**	42·2	**0·166**	**0·093, 0·239**
Spain	Liking	**0·213**	**0·148, 0·278**	**0·108**	**0·071, 0·145**	35·3		
	Self-efficacy	**0·156**	**0·098, 0·214**	**0·068**	**0·040, 0·097**	22·3		
	Perceived barriers	**−0·109**	**−0·168, −0·050**	**0·029**	**0·011, 0·047**	9·5		
	Liking, self-efficacy and perceived barriers			**0·205**	**0·166, 0·244**	77·2	0·060	−0·022, 0·143
Iceland	Attitude	**0·113**	**0·047, 0·179**	**0·035**	**0·013, 0·057**	11·6		
	Liking	**0·128**	**0·045, 0·210**	**0·040**	**0·013, 0·066**	13·2		
	Self-efficacy	**0·163**	**0·105, 0·220**	**0·067**	**0·041, 0·093**	22·2		
	Attitude, liking and self-efficacy			**0·142**	**0·112, 0·172**	46·9	**0·160**	**0·090, 0·231**
Denmark	Attitude	**0·100**	**0·043, 0·158**	**0·040**	**0·016, 0·064**	8·5		
	Liking	**0·212**	**0·141, 0·282**	**0·097**	**0·063, 0·131**	20·6		
	Self-efficacy	**0·209**	**0·153, 0·264**	**0·098**	**0·069, 0·127**	20·8		
	Attitude, liking and self-efficacy			**0·235**	**0·203, 0·268**	49·9	**0·236**	**0·169, 0·303**
Portugal	Liking	**0·397**	**0·334, 0·460**	**0·097**	**0·074, 0·121**	49·4		
	Self-efficacy	**0·136**	**0·089, 0·182**	**0·034**	**0·020, 0·049**	17·3		
	Liking and self-efficacy			**0·132**	**0·107, 0·157**	66·7	**0·066**	**0·003, 0·128**
Australia	Attitude	**0·079**	**0·017, 0·140**	**0·027**	**0·005, 0·049**	8·3		
	Liking	**0·224**	**0·154, 0·293**	**0·079**	**0·050, 0·107**	24·3		
	Self-efficacy	**0·160**	**0·106, 0·213**	**0·062**	**0·038, 0·086**	19·1		
	Perceived barriers	**−0·120**	**−0·179, −0·060**	**0·046**	**0·022, 0·070**	14·1		
	Attitude, liking, self-efficacy and perceived barriers			**0·213**	**0·177, 0·250**	65·8	**0·111**	**0·033, 0·189**
The Netherlands	Attitude	**0·069**	**0·024, 0·115**	**0·011**	**0·001, 0·022**	4·9		
	Liking	**0·212**	**0·153, 0·270**	**0·083**	**0·053, 0·112**	35·4		
	Self-efficacy	**0·150**	**0·106, 0·195**	**0·059**	**0·035, 0·082**	25·1		
	Perceived barriers	**−0·069**	**−0·136, −0·002**	0·016	−0·0002, 0·032	6·8		
	Attitude, liking, self-efficacy, perceived barriers			**0·169**	**0·133, 0·205**	72·2	0·065	−0·008, 0·312
Sweden	Liking	**0·277**	**0·211, 0·342**	**0·108**	**0·077, 0·139**	29·5		
	Self-efficacy	**0·167**	**0·113, 0·222**	**0·082**	**0·053, 0·112**	22·6		
	Liking and self-efficacy			**0·190**	**0·156, 0·224**	52·0	**0·175**	**0·102, 0·248**
Belgium	Attitude	**0·074**	**0·018, 0·129**	**0·015**	**0·003, 0·028**	6·0		
	Liking	**0·236**	**0·172, 0·300**	**0·072**	**0·048, 0·095**	27·8		
	Self-efficacy	**0·119**	**0·070, 0·168**	**0·047**	**0·026, 0·069**	18·4		
	Perceived barriers	**−0·103**	**−0·164, −0·043**	**0·029**	**0·011, 0·048**	11·5		
	Attitude, liking, self-efficacy and perceived barriers			**0·164**	**0·067, 0·260**	63·7	**0·093**	**0·033, 0·153**
Total	Attitude	−0·065	0·044, 0·085	**0·018**	**0·012, 0·024**	6·0		
	Liking	0·240	0·216, 0·264	**0·085**	**0·075, 0·095**	27·7		
	Self-efficacy	0·155	0·137, 0·173	**0·061**	**0·053, 0·069**	19·9		
	Perceived barriers	−0·058	−0·078, −0·038	**0·016**	**0·010, 0·022**	5·3		
	Attitude, liking, self-efficacy and perceived barriers			**0·180**	**0·169, 0·191**	58·8	**0·126**	**0·284, 0·331**

*Adjusted for gender and age and nested design.
Bold values represent significant effects/associations.

Table 5 Mediated effects ($a \times b$), proportion mediated ($a \times b/c$) and direct effects (path c′) of fruit availability at school on fruit intake in the final model in nine European countries

		β-Coefficient in final mediation model*		Mediated effect (a × b)		Proportion mediated	Direct effect of school availability on fruit intake (c′)*	
Country	Mediator	OR	95 % CI	OR	95 % CI	%	OR	95 % CI
Norway	Attitude	0·224	0·166, 0·281	0·051	0·033, 0·069	80·4	0·012	−0·024, 0·049
	Liking	0·354	0·003, 0·071	0·013	0·001, 0·025	>100 %†	−0·004	−0·039, 0·031
	–							
Spain	Attitude	0·116	0·059, 0·174	0·006	0·001, 0·010	38·0		
	Liking	0·235	0·163, 0·306	0·009	0·004, 0·015	63·1		
	Self-efficacy	0·230	0·173, 0·287	0·012	0·006, 0·018	79·3		
	Perceived barriers	−0·061	−0·118, −0·004	0·002	−0·0004, 0·004	10·7		
Iceland	Attitude, liking, self-efficacy and perceived barriers			0·042	0·025, 0·059	>100 %†	−0·013	−0·040, 0·014
	–							
	Attitude	0·299	0·243, 0·355	0·008	0·0003, 0·015	>100 %†	−0·009	−0·038, 0·019
	–							
Denmark	Attitude	0·270	0·217, 0·324	0·012	0·002, 0·021	25·3	0·034	−0·001, 0·070
	–							
	Attitude	0·081	0·061, 0·101	0·002	0·001, 0·003	14·0		
	Liking	0·270	0·246, 0·293	0·005	0·003, 0·008	38·7		
Portugal	Self-efficacy	0·178	0·160, 0·195	0·003	0·001, 0·005	23·0		
	Attitude, liking and self-efficacy			0·010	0·007, 0·013	75·7	0·003	−0·007, 0·013

*All analyses are adjusted for age and gender and for the nested design.
†Inconsistent mediation models, direct effects and mediated effects have opposite signs.
Bold values represent significant effects/associations.

sample, it seems that school availability is associated with fruit intake mediated by three mediating variables but is not directly associated with fruit intake. Since the observed overall relationships between school availability of fruit and fruit intake and the mediating pathways of this association differ across countries, this association and its underlying mechanisms are probably highly influenced by country differences in sociocultural environments and/or school environmental factors. Furthermore, it may also be that potential moderating variables play a role and that an association between school availability and fruit intake is only present in specific subsamples of the population. For instance, whether or not children bring fruit from home to school may have a moderating role. This was outside the scope of the present study, but needs to be explored in future studies.

That we did not find associations between school availability and fruit intake in most countries may be partly due to the so-called suppression effects by mediators included in the present study. This phenomenon has been described previously, and is present when mediated and direct effects have opposite signs. It also results in very high proportions of the total effect mediated. However, in the present study, the direct effects were not significant and very close to zero. Furthermore, MacKinnon *et al.*'s[33] suggestions for the interpretation of the third-variable effects say that in case of positive third-variable effects (i.e. positive mediation effects), direct effects (close to zero) and overall effects greater than the direct effects ($c > c'$), there is no evidence for mediation, confounding or suppression. Therefore, the findings for the mediation analyses for the relationship between school availability and fruit intake in the Spanish, Danish and Austrian samples should not be used, as they are derived from inconsistent mediation models[33].

Reinaerts *et al.*[34] did find that habit was an important factor related to fruit intake, although they also concluded that availability and taste preferences should not be ignored. Other studies also showed that home availability and taste preferences are among the strongest factors that are related to children's and adolescents' fruit intake[20,26,32,35,36].

Although availability of fruit has been found to be an important predictor of intake, it is just one type of environmental factor. Swinburn *et al.*[37] have conceptualized four different types of environment, i.e. physical (what is available), economic (what are the costs), political (what are the 'rules') and socio-cultural (what are the attitudes and beliefs). Therefore, similar mediation analyses using other environmental factors than availability, such as school food policies or costs of fruit, can be recommended.

In addition, children may bring fruit to school themselves, and thereby affect the availability of fruit during the school day. For some of the countries included in the present study, it is quite common that the children themselves bring fruit to school. In Austria, Denmark, Iceland, Norway and Sweden, more than one-third of

children said that they brought fruit to school on all or most school days (SJ te Velde, unpublished results). Such information has not been included in the measure of child-reported school fruit availability in the present study, and may have contributed to the low association between fruit availability at school and fruit intake.

Home and school availability of fruit was self-reported and thereby a measure of perceived availability, rather than an objective measure. However, children's perception of the environment might be more important in determining the mediated route of environmental influences on behaviour[23].

Some limitations of the present study should be mentioned. Owing to the cross-sectional design of the study, no conclusions can be drawn about causality or prediction. It is possible that attitude, preferences, self-efficacy and barriers influence home availability and this in turn influences fruit intake, so that home availability is considered as a mediating variable or that intake influences the presumed mediators and determinants. Further, longitudinal research should explore predictive associations between these factors. In order to assess the effects of mediators, longitudinal data would be more appropriate, as has been done by Bere *et al.*[38]. Another limitation is the assessment of intake and its potential-related factors by just a few self-reported items. We used data from the larger Pro Children study, in which a broad range of potential intake-related factors, and therefore only a few items per factor or single-item constructs were included. The questionnaire has, however, been validated before the study. However, the reliability of the scales were generally low, which impairs the ability to detect relationships. Finally, the participation rate of schools was rather low in some countries. Unfortunately, participation bias at the school level cannot be tested. Participation bias at the child level was caused by being present or not on the day of the data collection. All children who were present in the classroom participated in the study, and not being present was not a conscious decision of the children.

Multi-collinearity, i.e. strong correlations between the potential mediators, may have affected the multiple mediator analyses. However, inter-correlations between all mediators were below 0·60 (SJ te Velde, unpublished results).

The strengths of the present study were the validated instrument to assess intake and potential psychosocial and environmental related factors and the rather high response rates, although the participation rate at the school level was low in some countries, which might have introduced bias. Large, and in most cases representative, sample sizes from nine different European countries and applying mediation analyses while taking the nested design into account can be seen as the other strengths of the present study. Furthermore, the results of the study contribute to our understanding of the relationship between home or school availability of fruit and fruit intake among primary-school children.

Conclusions

The present study showed that liking and self-efficacy for eating fruit were the strongest mediators in the relationship between home availability as well as school availability of fruit and self-reported fruit intake among 11-year-olds. Home availability also showed a direct association with fruit intake. This is an indication that home availability of fruit may be a determinant to target in interventions promoting fruit intake among adolescents. Future research should include more reliable measures, a broader range of environmental factors and use longitudinal or experimental designs to further study the explored relationships.

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