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Comparison of the four co-created interventions to improve snacking and physical activity behaviour in European adolescents: the SEEDS project

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Abstract

Background New approaches involving adolescents in designing and implementing interventions are an opportunity to improve healthy lifestyles. This study aims to describe and analyse the differences and similarities between the four country-specific (Greece, Spain, The Netherlands and the United Kingdom) co-created interventions through a Makeathon by adolescents from the European Science Engagement to Empower aDolescentS (SEEDS) project, to tackle unhealthy behaviours. Also, it aims to determine if the barriers/facilitators identified in previous focus groups were addressed in the interventions.

Methods This comparative design study describes and analyses the differences and similarities among the four co-created interventions from the SEEDS project, which is a cluster-randomised controlled trial using a citizen science approach that actively involves participants in all steps of the scientific process. Two of the relevant steps are the definition of the barriers and facilitators by focus groups and the co-design of the interventions by Makeathons. The interventions co-created in each country related to healthy snacking and physical activity (PA) practice are described using the Template for Intervention Description and Replication (TIDieR) with some extra information about the country context (barriers and facilitators).

Results The four interventions have some points in common: type of activities per behaviour (methodology used), face-to-face activities, school hours implementation, and external professionals, teachers, or researchers as providers. However, the difficulties in comparing the interventions are the high diversity of activities and activity frequency among the four countries. About barriers, 2 of 3 modifiable barriers to healthy snacking behaviour and 4 of 6 modifiable barriers to PA and sedentary behaviour were addressed in the intervention, but 6 of 12 barriers to PA seemed not feasible for schools and not address in the intervention. Regarding facilitators, focusing on PA and sedentary behaviour, two of the four facilitators identified and focused on healthy snacking behaviour, and only one of the four facilitators identified was addressed in the interventions.

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Conclusions In four co-created interventions by adolescent ambassadors, most of the barriers identified were addressed whereas the facilitators were not enough addressed. Thus, more effort is needed to completely adapt the intervention to the real interest of adolescents. Future research needs to confirm the SEEDS intervention effect and impact on the desired behaviour.

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Keywords Citizen science, Co-creation, Makeathon, Adolescents, School-based intervention

Background

Adolescence is a crucial time for building the foundations of good health such as diet and physical activity (PA) practice [1]. The last Health Behaviour in School-aged Children (HBSC) report showed that less than 20% of European adolescents meet the World Health Organization (WHO) PA recommendations of at least 60 min of moderate-to-vigorous PA each day, mostly aerobic [2]. Related to dietary behaviours, two in three adolescents do not eat daily fruits and vegetables [2] as WHO recommends it. In addition, one in four adolescents eat sweets at least once a day, and one in six consumes sugary drinks at least once a day [2], which is an excessive consumption of sugary products.

Another aspect is that unhealthy lifestyles like physical inactivity and poor diet are important risk factors for non-communicable diseases [3]. Additionally, social inequalities persist in PA and dietary behaviours because adolescents with low socioeconomic status (SES) have poorer healthy behaviours compared to their peers with a high SES [2].

All mentioned above highlights the importance of promoting healthy lifestyle behaviours to create good health in adolescents [2]. Adolescents need opportunities to feel involved in the design and implementation of interventions to improve their lifestyles [1]. However, adolescents from deprived areas may be considered a hard-to-reach group [4] and adolescents from deprived areas have fewer opportunities to participate in science and more difficulties in having a good level of science [5].

Evidence about school-based and community-based interventions for adolescents to improve their lifestyles demonstrated small effects in improving PA [6] or obesity outcomes [7].

The WHO emphasizes the importance of empowering adolescents, and providing them with the critical skills, confidence, and resources to make their own decisions [8]. Moreover, participatory research approaches emerged as a new way to empower adolescents, showing a higher level of engagement of participants, working together with researchers to improve their own health and well-being [9]. Additionally, participatory research engages relevant stakeholders with the potential to influence the target group, as a way to increase the efficiency of intervention to achieve positive changes [10].

In the last decade, evidence for community-based participatory research and youth-led interventions to improve healthy eating and PA practice engaging children and adolescents in different settings, like schools and communities, has been growing [11–14]. These participatory research types of interventions can involve participants in different stages of the project, such as data collection, intervention development, data interpretation and dissemination [11–14]. A recent narrative review described a big heterogeneity of participatory research approaches and methods used in the development of health interventions for children and/or adolescents such as the use of community-based participatory research, co-creation, participatory design, and user-centred design [15]. Although this review provides valuable practical guidance for using these participatory approaches, only a few of them evaluated the effectiveness of the participatory research approaches [15]. A new systematic review and meta-analysis evaluated the effectiveness of participatory research interventions and concluded they may be effective in obesity-related healthy lifestyle behaviours, however, the overall results were inconclusive due to the limited amount and heterogeneity of studies [16].

Additionally, the evidence showed other participatory research approaches described as a collaborative process like Citizen Science (CS) [17]. CS aims at engaging and actively involving citizens in generating new scientific knowledge whilst producing scientifically legitimate and reliable results [18]. There are multiple definitions of CS although, the European Citizen Science Association (ECSA) defined the 10 key principles to achieve good practice in CS [19]. One of the most important is the participation of the target audience in multiple stages of the scientific process: from developing the research question to disseminating the results [19]. Most CS projects were implemented in scientific disciplines like ornithology, palaeontology, astronomy, and atmospheric sciences [20]. Health is relatively under-represented in CS, although CS approaches are increasingly being used in chronic disease prevention to support community health and well-being, especially in PA and/or nutrition issues [21].

From this CS perspective, the Science Engagement to Empower aDolescentS (SEEDS) project used a CS approach through focus groups and co-creation to actively involve the participants in the scientific process,

promoting their critical skills and abilities to make their own decisions [22]. The SEEDS project aimed to listen to and empower adolescents living in deprived areas (disadvantaged adolescents) in four European countries, Spain (Reus), the United Kingdom (Exeter), the Netherlands (Rotterdam) and Greece (Athens), to make a change towards a healthy and active lifestyle and increase interest in Science, Technology, Engineering and Mathematics (STEM) [22].

In the CS approach, focus groups facilitate participation and shared decision-making with participants [17]. A focus group is a qualitative data collection method defined as a reduced discussion group interview of 1–2 h duration to obtain in-depth knowledge about the attitudes, perceptions, beliefs and opinions of participants regarding a specific health topic or issue [23, 24]. In the SEEDS project, focus groups were mainly used to identify barriers and facilitators affecting healthy lifestyle behaviours of adolescents.

Furthermore, a co-creation process through a Makeathon (people work together on solutions to a specific problem by collaboratively creating tangible and creative things within a given time frame) [25] with ambassadors and their peers supported by stakeholders and young facilitators was organized to develop school-based healthy lifestyle interventions [22].

The aims of the present work are:

1. To describe and analyse the differences and similarities between the four country-specific co-created interventions through a Makeathon by adolescents from the SEEDS project, to tackle unhealthy behaviours: (1) dietary behaviour and (2) PA and sedentary behaviour.
2. To determine if the barriers and facilitators of adolescents identified in the focus groups by adolescents of each country, implemented during the SEEDS project, were addressed in each co-created interventions focused on improving the (1) dietary behaviour and (2) PA and sedentary behaviour.

Methods

Design of study

The SEEDS project is a multicentre cluster-randomised controlled trial carried out in four European countries: Greece (GR), The Netherlands (NL), the United Kingdom (UK), and Spain (SP), using a CS approach. The CS approach implemented in the SEEDS project consists of actively involving adolescents from high schools located in deprived areas in different steps of the scientific process such as the data collection (focus groups), design (Makeathon), implementation of the intervention, and dissemination of the project. The methodology of the SEEDS project is explained in depth in the study protocol

[22]. The present comparative design study [26] describes and analyses the differences and similarities among the four different six-month interventions (from each European country) co-created during the SEEDS project by adolescents. The SEEDS project had five phases:

- 1) High school, ambassador, and peer recruitment: high schools were recruited from low-income or deprived neighbourhood. Then, the adolescents between 13 and 15 years old from these high schools were recruited, and some of them were selected by the teachers as ambassadors (leaders) from intervention high schools of each country, considering their leadership skills. Ambassadors were representatives of their school or the different classrooms participating.
- 2) Focus groups: one with ambassadors and the other with stakeholders (explained in depth below).
- 3) Pre-post-assessment of the intervention: all the participants from intervention and control high schools completed questionnaires related to healthy and active living and STEM outcomes at baseline and the end of the intervention.
- 4) Intervention: (1) Makeathon: design intervention activities in a co-creation process through a Makeathon event with the collaborative participation of ambassadors or ambassadors and their peers, stakeholders, and young facilitators (people who act as a near link with participants like Master and PhD Students related to health topics); (2) implementation of the intervention in high schools with the collaboration of ambassadors, teachers, stakeholders, researchers and/or external professionals.
- 5) Dissemination of the project: the ambassadors of the intervention high schools of each country travelled to Brussels to disseminate the interventions co-created in their high school and the results of their interventions to the rest of their European peers. Also, they expressed their experience as ambassadors of the SEEDS project.
- 6) Focus groups: From each of the four target countries, at least two focus groups were developed: (1) one focus group with a minimum of three ambassadors and (2) one focus group with stakeholders. The duration of them was a maximum of 75 min. The focus groups were audio-recorded, transcribed, and translated into English.

Focus groups

From each of the four target countries, at least two focus groups were developed: (1) one focus group with a minimum of three ambassadors and (2) one focus group with stakeholders. The duration of them was a maximum of

75 min. The focus groups were audio-recorded, transcribed, and translated into English.

- 1) The focus groups with ambassadors aimed to gain insights about the barriers and facilitators related to healthy snacking and active living behaviours and how to engage their peers in the different phases of the project. Moreover, ambassadors could choose an extra healthy lifestyle behaviour to address in the intervention. However, ambassadors from Spain were the only that selected an extra behaviour (screen time).
- 2) The focus groups with stakeholders aimed to discuss the barriers and facilitators identified in the focus group made with ambassadors, to indicate the feasibility of changing the behaviours in the 6-month intervention and, to identify the role of stakeholders in the SEEDS intervention like supporting adolescents to overcome barriers [22].

Co-creation process: Makeathon

The summary of transcriptions of each focus group's insights led to drawing up the two questions related to the two behaviours that guided the co-creation process through a Makeathon: (1) "What experiment would you create to improve snacking and drinking inside or outside your school?"; and (2) "What experiment would you create to be more physically active and sit less during the school day?".

The Makeathon was a co-creation event where ambassadors or ambassadors and their peers actively participated to create and develop the intervention to be implemented in high schools. The Makeathon lasted 2–5 h and consisted of various steps explained in depth in the SEEDS protocol article: empathise (general introduction), define (presentation of the challenge), ideate (generate ideas), prototype and test (develop and test ideas), pitch (expose ideas), a summary of the event, and evaluation (evaluation questions about the event) [22].

One Makeathon per high school or a single Makeathon with all high schools was carried out, depending on the COVID-19 situation and feasibility. Young facilitators supported and guided the adolescent Makethon participants in the phases of co-creation without participating actively, and stakeholders supported adolescents in the creation, development, and testing of interventions without diminishing or influencing their ideas.

After the co-creation event, the researchers discuss the intervention co-created by adolescents and define the final version of the intervention following the Template for Intervention Description and Replication (TIDieR). Then, the final intervention was exposed to the ambassadors to obtain their agreement.

Participants

The SEEDS project targeted high schools located in low socioeconomic neighbourhoods defined by different statistical official tools in each country [27–31]. In each country, the recruitment process was:

- a) the high schools received an information letter explaining the study,
- b) when once high schools agreed to participate in this project, the high schools were randomised to an intervention (IG) or control group (CG),
- c) then, 13–15 years old adolescents from high schools located in socioeconomically disadvantaged areas, representing a low socioeconomic status, were recruited,
- d) finally, adolescents and their parents/caregivers signed the informed consent to participate in the project.

In addition, in each country, 16–21 adolescent ambassadors from high schools assigned to the IG were recruited by teachers considering their leadership skills [32, 33].

A total of 12 IG and 14 CG high schools were recruited. However, the present study focused only on intervention high schools because the focus groups and intervention development were only performed with participants of IG whereas CG maintained their habitual activity.

Data analyses of co-created interventions and insights obtained from focus groups

In the first part of the present study, the four co-created country-specific interventions related to healthy snacking behaviour and, PA and sedentary behaviour, were described and assessed by TIDieR [Additional file 1], a quality checklist to describe interventions [34]. The TIDieR checklist details important intervention aspects and was used to identify similarities and differences between the four interventions and activities focused on healthy snacking behaviour or PA and sedentary behaviour. The sections are: (1) **Brief Name**: phrase describing intervention; (2) **Why**: rationale, theory, or goal; (3) **What**: materials and procedures, specifically the methodology used (training, lessons, workshops, challenges, competitions, etc.); (4) **Who** provided: expertise, background and any specific training; (5) **How**: modes of delivery the intervention; (6) **Where**: location(s); (7) **When and How much**: number of sessions, schedule, duration, intensity or dose; (8) **Tailoring**: If the intervention was planned to be personalised, titrated or adapted; (9) **Modifications**: describe the changes (what, why, when, and how); and (10) **How well**: intervention adherence or fidelity assessment and strategies were used to maintain or improve fidelity. Moreover, considering the importance of adapting the interventions to the

Table 1 Description of intervention activities of each country by TIDieR components and barriers and facilitators experienced by adolescents

Country	Intervention activities	What	Who	How		Where	When and how much		How well	Modifications	Barriers addressed	Facilitators addressed
				Delivery format	Intervention Location		Duration	Number of sessions				
PA and sedentary behaviour												
Greece	Large variety of activities in PE classes	Wider variety of alternative non-competitive activities to increase engagement in classes + new equipment + leaflet promoting an active lifestyle and useful tips posted in classes	PE teachers + ambassadors	Face-to-face Group	PE classes (high school)	5 months NR	Meetings face-to-face with ambassadors and stakeholders (55.6%)	NR	Lack of variation in sports and activities during the PE classes Lack of clean material in PE classes	Peers and teacher support		
Spain	Sport day	Sports day (tournaments, traditional games, dance...) selected by peers preferences	Sports instructors + PE teachers + peers	Face-to-face Group	High school	4 h 1 session	Attention list (61.8%)	NR	Lack of variation in sports and activities during the PE classes			
	Training adolescents and parents	Training to adolescents and families about healthy snacks, PA and screen-time + workshop about organization of time	Researchers	Adolescents: Face-to-face Group Parents: Online Group	Adolescents: High school Parents: Teams platform (home)	Adolescents: 1 h and 30 min 1 session Parents: 1 h (20 min webinar) 1 session	Attention list (Adolescents: 82.9% Parents: 13.5%)	NR				
	Active class (1) and active breaks (2)	(1) Active classes in the classroom/ playground/ outside the high school (2) 8 short videos with different exercises to do in long-term classes or between classes	(1) Teachers (2) PE professional	Face-to-face Group	High school	(1) 4 months 1 session/month (2) 4 months 2 sessions/month	Attention list (47.1%)	(1) COVID situation + high school activities organized make difficult the accomplishment of frequency	Long-time sitting down			

Table 1 (continued)

Country	Intervention activities	What	Who	How	Where	When and how much	How well	Modifications	Barriers addressed	Facilitators addressed
The Netherlands	Workshops of new sports	(1) flag-football workshop for grades 1–3	(1) PE teachers + ambassadors;	Face-to-face	(1) PE classes (High school)	(2) 1 h and 30 min	Register (1) 7.3%	NR	Lack of variation in sports and activities during the PE classes	Peers
		(2) baseball workshop	(2) Researchers	Group	(2) After school hours (in high school)	1 session	(2) 3.6%			
The United Kingdom	Actively participate in PE classes	PA opportunities during breaks	Youth workers + ambassadors	Face-to-face	High school	2 months	Register (9.1%)	NR	Long-time sitting down	Peers
		Brainstorm with local policymakers to select and organize ideas → organized small tournaments during the breaks + created a poster	Researchers + ambassadors and peers	Face-to-face	PE classes (high school)	2 months	Meeting virtually and face-to-face with participants (19.6%)	NR		
The United Kingdom	Get active	Challenge to increase progressively the active days per week and the minutes of activity inside and outside high-school	Researchers + ambassadors and peers	Face-to-face	High school and outside	4 months	Meeting virtually and face-to-face with participants (NR)	NR	Long-time sitting down	Peers
		Challenge to skip for two minutes + 'Intervention Pack' based on a good quality skipping rope	Researchers + ambassadors and peers	Face-to-face	High school and outside	1 month	Meeting virtually and face-to-face with participants (15.2%)	NR	Some participants did not enjoy skipping → they practiced in other sports (cardiovascular exercise session following an instructor via a YouTube video)	Peers

Healthy snacking behaviour

Table 1 (continued)

Country	Intervention activities	What	Who	How	Where	When and how much	How well	Modifications	Barriers addressed	Facilitators addressed
Greece	Healthier school canteen	School canteens bring healthy snacks+ school canteen catalogue poster outside the canteen+ leaflet about healthy snacking at school by ambassadors	Researchers + ambassadors	Face-to-face Group	High school canteen	5 months NR	Meetings face-to-face with ambassadors and stakeholders (18.5%)	Low motivation → informative poster about healthier canteen choices on school billboards + oral repromotion by the researcher and ambassadors	School canteen offered unhealthy snacks	
Spain	Training for adolescents and parents	Training about healthy snacks, PA and screen-time + workshop about time organization	Researchers	Adolescents: Face-to-face Group Parents: Online Group	Adolescents: High school Parents: Teams platform (home)	Adolescents: 1 h and 30 min 1 session Parents: 1 h (20 min webinar) 1 session	Attended dance list (Adolescents: 82.9% Parents: 13.5%)	NR		
	Workshop healthy snacks	Workshop to learn basic cooking skills and easy recipes for healthy snacks + booklet with recipes	Cook and nutrition education company + researchers	Face-to-face Group	High school	1 h 1 session	Attended dance list (81.2%)	NR		
	Competition of healthy snacks + fruit service	Competition consisted of eating healthy snacks and the ambassadors registered the peers' snacks on a checklist + free service of fruit	Local fruit providers + ambassadors + teachers	Face-to-face Group	High school (Tutorial classes)	3 months Competition: 1–2 times week Fruit service: 2 times per month	Checklist (Competition: 61.2% Fruit service: 71.2%)	NR	Students did not eat anything at high school (irregular meals)	High school

Table 1 (continued)

Country	Intervention activities	What	Who	How	Where	When and how much	How well		Modifications	Barriers addressed	Facilitators addressed
							Intervention type	Intervention Provider			
The Netherlands	Creating healthy school canteen	A project group discussed which food and drinks to provide in the healthy school canteen and how it should look like	Ambassadors + teacher + canteen representative + expert school canteens	Face-to-face Group	High school	4 months 3 sessions (45–90 min)	NR (9.1%)	NR	School canteen offered unhealthy snacks	High school	
	Lessons package about nutrition	Lessons about healthy eating + discussions about it by teachers in regular classes	Dutch nutrition institute	Online at high school Individual	Home	4 months 10 sessions of 30 min	NR	NR			
The United Kingdom	Cooking workshop	Workshop focusing on how to make tasty food also healthy	External professional from Voedseleducatie010	Face-to-face Group	High school (extracurricular)	2 months 3–4 sessions	Register (25.5%)	NR			
	Eat healthy snacks	Explanation about the fundamental basics of healthy eating + challenge to increase progressively the healthy snacks eaten each week	Researchers + ambassadors and peers	Face-to-face Individual	High school or home	3 months 1–4 times per week	Meeting virtually and face-to-face with participants (9.8%)	NR	Students did not eat anything at high school		

Abbreviations: PA, Physical Activity; PE, Physical Education; NR, Not reported

context of these adolescents, taking into account their socio-cultural and environmental situation, adolescents experienced barriers and facilitators were introduced as complementary variables in the TIDieR checklist.

In the second part of this study, we investigated whether the barriers and facilitators related to healthy snacking and, PA and sedentary behaviour, mentioned in focus groups, were addressed in the interventions of each country.

- Barriers and facilitators were extracted from the summary of transcribed information from audio-recorded focus groups with ambassadors in each country.
- Then, the insights about the two behaviours from focus groups led to the creation of the two questions that were addressed in the co-creation process (Makeathon). Also, these focus group insights allowed knowing the socio-cultural and environmental situation of each country's participants, which is relevant for adaptation of the co-created intervention to the cross-cultural difference in each country.

Results

Description and comparison of the four co-created interventions according to the TIDieR checklist

Activities of all interventions took place in the first six months of 2022. The interventions were divided into two components, healthy snacking behaviour activities, and, PA and sedentary behaviour activities. The intervention of each country is explained in depth in Additional File 2. However, a summary of each country's intervention using the TIDieR checklist is detailed in Table 1.

TIDieR Section 2: Why

The goal of healthy snacking behaviour activities was to improve the choice of healthy snacks inside and/or outside the high school and, the goal of PA and sedentary behaviour activities was to increase PA and reduce sedentary time inside the high school.

TIDieR Section 3: What (intervention type)

The types of co-created activities (methodology used as is explained in the methods section) focused on improving healthy snacking behaviour were similar among countries. GR and the NL focused on a healthier school canteen, but in the NL the participants worked on some sessions to improve the healthiness of the canteen. They carried out the next multiple steps (implemented the change in the canteen) during the present scholar year (2023–2024). SP and the NL, both focused on a training and cooking workshop about healthy eating. Finally,

the UK and SP organized a challenge or competition for healthy snacks.

The types of co-created activities to improve PA and reduce sedentary behaviour in school are similar among countries. In SP and NL, workshops to practice new sports were organized. The UK and GR both focused on more active participation in PE lessons. Lastly, SP, the NL and the UK all focused on active breaks during school hours.

TIDieR section 4: Who (intervention provider)

The activities focused on healthy snacking behaviours were provided by external professionals (SP, NL), owners of the canteen (NL, GR), or researchers with the collaboration of ambassadors and peers (NL, UK, GR). The activities related to PA and sedentary behaviours were provided by PE teachers when implemented in PE classes or by researchers with the collaboration of ambassadors and peers, and by external professionals like sports instructors and youth workers (SP and NL).

TIDieR sections 5 and 6: How and Where (delivery format and location of intervention)

Most intervention activities were implemented during school hours (in high school) and face-to-face. The PA and sedentary behaviour activities were implemented during PE classes and breaks between high school classes. However, healthy snacking behaviour activities were implemented at different moments of the day: during school hours (GR, SP, NL, UK), outside high school (NL, UK), and during extracurricular hours in high school or online at high school (NL).

TIDieR section 7: When and How much (duration and number of sessions activities of intervention)

Whilst the type of activities was similar, the duration and frequency (sessions) of activities differed greatly. Some activities were only organized once, whereas others had a frequency of a couple of times a week for several months.

TIDieR section 10: How well (compliance of intervention and method to register compliance)

The compliance of intervention is defined as the active participation in the activities of each country's intervention. The method to register compliance was by participation in the activities mostly using a list/checklist of activities attendance, or recurrent meetings with ambassadors to know how the activity was going on and the attendance at activities. In addition, in the final assessment questionnaire of the project, all participants were asked about their participation in each activity of their country's intervention. The compliance of healthy snacking behaviour activities ranged from 9.1 to 81.2%, and PA and sedentary behaviour activities ranged from 9.1 to

82.9%. In general, the biggest compliance rate was in the SP intervention (activities mean of 59.8% in all activities) and the lowest compliance rate was in the NL intervention (activities mean of 10.9%).

Overall, the SP and NL interventions had many similar types of activities between them such as in the healthy snacking behaviour, training with adolescents and cooking workshop; and in the PA and sedentary behaviour with the implementation of active breaks and workshops to practice new sports. The UK had at least one common activity for each behaviour with the other countries (active breaks with SP and NL, competition of healthy snacks with SP and actively participating in PE classes with GR). GR only had one common activity with NL (healthy canteen) and another with the UK (actively participating in PE classes). In addition, the GR intervention was composed of one activity per behaviour whereas the other countries' interventions were composed of at least two activities per behaviour.

Ambassadors identified barriers and facilitators addressed in the interventions

A summary of barriers and facilitators per country is explained in Table 2.

Barriers

Focusing on healthy snacking behaviours, two countries (GR and NL) detected the school canteen offering unhealthy snacks as a barrier. This aspect was solved with a similar activity in those countries, which was adding healthier food choices in the school canteen (GR) and creating a healthy school canteen (NL). The other common barrier detected was that students did not eat anything during high school hours (SP and UK). The SP intervention tried to solve this with the competition for healthy snacks and the free fruit service, and the UK intervention launched a challenge to progressively increase the healthy snacks eaten each week.

Regarding barriers to PA and sedentary behaviour, there are two common barriers in all countries: insufficient space and time during breaks to be active and a long time sitting down during school hours (GR, SP, NL, and UK). The long-time sitting down was solved by some activities like active classes and active breaks (SP), more PA opportunities during breaks (NL) and getting active during school hours (UK). However, the GR intervention did not have any intervention activity to address these barriers. Additionally, a barrier to the lack of variation in sports and activities during PE classes was detected in three countries (GR, SP, and NL). All of three countries addressed the lack of variation in sports with an intervention activity. Either by organizing activities related to practising new sports (SP, NL) or extending the variety of activities during PE classes (GR). Even though the

UK ambassadors did not detect this barrier in the focus groups, they co-created an intervention activity as a challenge to participate actively in PE classes.

Even though, the barrier of the lack of clean material in PE classes was only mentioned by GR and was addressed by providing better and new equipment for PE classes.

Moreover, some barriers depending on external factors (non-modifiable barriers) were not tackled within interventions, including the insufficient space and time during breaks to be active (GR, SP, NL and UK), duration and frequencies of PE classes per week (GR and NL), the warm temperatures during the summer season that burden the PA practice (GR and SP), tiredness of students and conserve energy to school work (GR and UK), among others.

Facilitators

Focusing on healthy snacking behavior facilitators, two common facilitators were detected in different countries. The first one was that the high schools did not allow students to bring energy drinks (SP and NL), however, they can consume them outside the school. For this reason, a workshop/training for adolescents about healthy eating and/or PA to increase adolescents' understanding of the importance of snacking healthy eating and PA practice (SP and NL), and a cooking workshop about healthy snacks, were implemented to have ideas to bring to school or cook at home (SP and NL). In SP, the high school, specifically, the Department of Education, was seen as a facilitator, as they provided breakfast to students with economic difficulties. Moreover, to reinforce healthy snacking an activity of SP intervention focused on offering a free fruit service in high schools.

The second common facilitator detected by NL and UK was parents' restriction or control of unhealthy snacks consumed by adolescents, but any activity of the NL and UK intervention involved parents as facilitators. One of the reasons for the non-involvement of parents was the restrictions of the COVID-19 pandemic in high schools which did not allow for the entrance of external people in some countries (NL, SP). In the SP intervention, despite the ambassadors not identifying the parents as a facilitator, e-learning training about snacking healthy eating and PA practice was implemented for parents of adolescents.

Regarding facilitators of PA and sedentary behaviour, the influence of peers to motivate participants to get active during school hours and PE classes was detected in three countries (GR, NL and UK), however, peer influence was also identified as a barrier to being active during recess in two countries (GR and UK). The peer influence is a facilitator may be addressed in all the interventions because the SEEDS project empowered the ambassadors and their peers involving them in the design and implementation of the interventions about PA. For example,

Table 2 Summary barriers and facilitators identified in each country by ambassadors

Country		Barriers	Facilitators
Greece	PA	School hours: - Insufficient space and time to get active during breaks* - Tiredness at the end of the school day* - Long-time sit-down during classes - Sit-down and talk with peers during breaks PE classes: - Duration and frequency of the classes* - Warm temperature in summer* - The lack of variation in the activities - Lack of clean mattress equipment - Students do not want to wear athletic outfits*	PE classes: - Teacher support - Take their mind off the daily pressure of the lessons and have fun with their friends (peers)
Spain	Snacking	- The school canteen offers limited (healthy) choices	
	PA	School hours: - Teacher inflexibility to be active during classes and breaks - The lack of time between classes to be active* - Long-time sit down - A lot of theory classes PE classes: - Warm temperature in summer* - The lack of variation in the activities - The unbalance of the groups during activities	
	Snacking	- Irregular meals during school hours (some students did not bring breakfast at high school) - Influence of friends' decisions related to unhealthy snacking outside high school	- Rules about sweets and energy drinks at high school - Providing healthy sandwiches for students with economic difficulties
Netherlands	PA	School hours: - Lack space to move during the breaks* - Long-time sit down PE classes: - Duration and frequency of the classes* - Lack of space* - Girls do not want to compete against boys (unbalanced) - Students do not like activities in front of the whole class* - Peers' complaints (demotivate the others) - The lack of variation in the activities	School hours: - Peers (do the same thing during recess) - Opportunity of extracurricular activities at school
	Snacking	- Breaks are too short to eat* - Not much healthy food and drinks options in the vending machine or the canteen	- Rules about energy drinks at high school - Parents restriction of unhealthy snacks consumption
United Kingdom	PA	School hours: - Insufficient space to get active during breaks* - Long-time sit down - Sit down and talk with peers during breaks - Conserve energy to focus on school work*	School hours: - Opportunities to be active during classes PE classes: - Gets competitive and work together with their peers.
	Snacking	- Some students do not eat anything during school hours	- Students can request their parents to add healthier options to shopping basket - Near accessibility of healthy snacks (near shops) - Teachers support

*non-modifiable barriers

ambassadors created leaflets promoting an active lifestyle to be more active during school hours (GR) and ambassadors organized small tournaments during the breaks and created a poster to be more active during school breaks (NL).

Additionally, teacher support was identified as a common facilitator but for different behaviour, to be more active in PE classes in GR and for improving healthy snacking in the UK. The facilitator was only addressed by

an activity involving PE teachers to offer a large variety of activities in PE classes in GR.

The common facilitators were family influence in healthy snacking behaviour, and peers in PA and sedentary behaviour.

The summary of the barriers and facilitators addressed in the intervention healthy snacking behaviour and, PA and sedentary behaviour is shown in Table 1.

Discussion

This study aimed to describe and compare the four country-specific co-created interventions to tackle unhealthy behaviours: (1) snacking behaviour and (2) PA and sedentary behaviours. It also sought to determine if the barriers and facilitators identified in the focus groups are addressed in the four co-created interventions.

The four co-created interventions generated by a Makeathon have key points in common analysed by the TIDieR checklist. The type of activities (methodology used as is explained in the methods section) and the delivery format were based on practical face-to-face activities like training, lessons, workshops, challenges, and competitions.

Focusing on location and providers, most activities are implemented during school hours in high school mainly by external professionals (like PE professionals, youth workers, local fruit providers, nutrition education companies, etc.), high school teachers, or/and, sometimes, by the project researchers with or without ambassadors' collaboration.

However, the duration and frequency of the activities differed among countries. The socio-cultural and environmental situations like accessibility and availability, resources, cultural beliefs, etc. in each country can be perceived as barriers or facilitators and a reason for selecting the characteristics of co-created activities [35]. Additionally, two countries, SP and GR, showed more than 50% rate of compliance and the other two, NL and UK, showed a low rate of compliance about less than 30%. The low rate of activity compliance can be explained because in the NL and UK, during the implementation of the intervention, the COVID-19 restriction influenced strongly scholar attendance [36, 37]. Whereas, in GR and SP the restrictions were more indulgent with the scholar present attendance. Additionally, some activities in NL had a limited number of participants to guarantee the well going of the activity, limiting the range of participation. The heterogeneity among co-created interventions difficult the comparison between countries and suggests the necessity of standardization. Future studies for avoiding heterogeneity, should develop a common co-creation process with the participation of all adolescents from each country taking into account the barriers identified in each country, or from the barriers identified by adolescents of each country, create a common catalogue of activities that could be effective to address each of the barriers identifies.

Since the TIDieR checklist does not include information on adaptation to the context of the target population, two extra components were added to specify the barriers and facilitators identified by participants in the different countries.

In summary, two of three modifiable barriers (possible to change) to healthy snacking behaviour were addressed in the intervention and four of six modifiable barriers to PA. Six of 12 barriers to PA seemed not feasible for schools and are not addressed in the intervention. Focusing on facilitators, not all were taken into account in interventions. Related to healthy snacking behaviour, only one of the four facilitators identified was addressed in the interventions; and focusing on PA and sedentary behaviour, two of the four facilitators identified were addressed in the interventions.

Previous studies described some common healthy eating and PA behaviours barriers in line with our study: (a) the limited PA opportunities during school hours and breaks, (b) the lack of students' choice/autonomy in PE classes, (c) the type and quality of food items in the canteen, (d) the lack of variety or the easy access to unhealthy food near the school [38, 39]. According to the present study results, the influence of peers and family was identified as a facilitator in PA and healthy eating, respectively [35, 38, 39].

Previous literature on school-based interventions targeting healthy lifestyle behaviours such as nutrition and PA outcomes without a participatory research approach [40–42], combined some theoretical activities including web-based interventions such as motivational text messages through technology, guidebooks, workbooks, seminars, and educational lessons and posters given by professionals for students, teachers or parents. Also, some practice activities to change the environment such as healthier food options in the canteen or vending machines, serving breakfasts in the classrooms to ensure the students eat a healthy meal and, cooking workshops [30–34]. Related to PA behaviours, most non-co-created interventions combined educational materials (theoretical activities) and changes to the school environment and/or school curricula (such as active lessons and recess, high-intensity activity in PE classes or increasing the frequency or duration of PE classes or sessions) [40–42].

Compared to the SEEDS project, in previous literature, there was a predominant use of theoretical activities in dietary behaviours instead. In the SEEDS project, practical activities (environmental change activities), challenges, and competition activities related to PA and dietary behaviours were included [40–44]. In addition, the previous evidence is focused on increasing the intensity and frequency of PE classes [40–44] but not increasing the variety of sports practised in classes as stated in the SEEDS project. Thus, the variety of sports may be the key to adolescents being active during PE classes.

However, some common points between previous school-based intervention studies and the SEEDS project are shown: the predominant face-to-face activities, the

implementation of the intervention during school hours, practical activities on PA behaviour, the use of training, lessons, and workshops related to healthy eating behaviours [40–44].

Although SEEDS project activities seem to be similar between the four countries, adaptation of interventions to the socio-cultural and environmental situation, that is, to the local barriers and facilitators of participants is crucial to allow adherence and effectiveness to interventions and ensure long-term sustainability results [35, 39, 45]. Additionally, the recent literature showed that the detection of barriers and facilitators related to lifestyle behaviours in adolescents is the key to the future design and implementation of interventions [35, 38, 39, 46, 47], as shown in the SEEDS project. Because of that, like we have done in this study, we recommend to add perceived barriers and facilitators addressed in an intervention as extra components to the TIDieR checklist to know the socio-cultural and environmental situation of the target population.

Thus, following this principle of identifying barriers and facilitators, the SEEDS project first conducted focus groups aimed at identifying such barriers and facilitators, before organising a Makeathon with adolescents to develop the interventions. Two questions, which focused on healthy snacking, and PA and sedentary behaviour beneficial changes, were used in the intervention co-creation process. Although ambassadors and/or their peers did not have the whole list of barriers and facilitators, mentioned in focus groups, during the Makeathon, a connection between the co-created interventions and the barriers previously identified exists. However, the common facilitators detected in the SEEDS project such as family influence in snacking behaviours and peers influence in PA and sedentary behaviours, were not fully addressed in the interventions. In future projects, it is recommended to take more explicitly into account the identified barriers and facilitators when developing the interventions and adapting the instructions for the Makeathons, starting with an explanation of the role of barriers and facilitators and having the list available from focus group.

Currently, limited evidence is available regarding identified insights, including barriers and facilitators, in focus groups before the co-creation and implementation of interventions, unlike the SEEDS project that used this innovative process. A recent systematic review of methods and approaches to improve health outcomes that enable children, adolescents, families, and carers to be involved in a participatory approach yielded twenty-six studies. Seven of them used focus groups as an integral method to co-design, co-produce, or co-create interventions that aligned with the definition of co-creation in the present manuscript [15]. However, this systematic

review did not analyse the effectiveness of the interventions [15]. In the literature, the focus group method is used as a tool to collect data in different steps of a participatory research study: (a) Before the co-creation: information from the focus group can provide some insights into the co-creation of the intervention [48, 49]; (b) During the co-creation process: the focus groups are used for the ideation/design stage previous to the co-creation of interventions [50–52]; and (c) After the design of interventions to gather feedback from participants and improve future interventions [53–55].

For all mentioned above, the recommendations for future co-creation of interventions in participatory research studies are: conduct focus groups to identify barriers and facilitators before the co-creation process, and explain the importance and use a list of barriers and facilitators detected in focus groups during the co-creation process to ensure they will be addressed in the co-created interventions. These recommendations applied to the co-created interventions, guarantee the feasibility that the co-creation process is linked to the intervention aims, and so do not guarantee the effectiveness of the interventions to improve the aims (healthy snacking and PA behaviour).

The SEEDS project contributes to the literature with new information about the importance of design interventions adapted to the target group's real identified barriers and facilitators related to healthy snacking behaviour and, PA and sedentary behaviour.

However, some limitations are detected. Firstly, the limited time to refine the co-created interventions in the Makeathon before carrying on the final intervention. Secondly, there is a selection bias related to the selection of ambassadors using leadership skills and in consequence, missing the perspectives of less-engaged adolescents. A random selection should ensure a more representative input. Thirdly, another limitation is the difficulty in addressing some of the barriers because, for example, the frequency or duration of the PE classes depends on adolescent external agents like the norms of the high school or department of education. In addition, the focus groups only consider the opinion of ambassadors, however, when the intervention is co-created by ambassadors and other peers in Makeathon, as in SP and GR, new barriers or facilitators were identified during the co-creation of the intervention. Thus, new barriers and facilitators were taken into account when developing the intervention activities. Another limitation is that some of the activities were provided with the budget of the researchers to hire external providers. This aspect can affect the sustainability of the activities implemented in the intervention after the study cessation due to the limited school's budget. That is, the involvement of stakeholders with a stakeholder partnership approach (external professionals

or community organizations) is a key aspect that could help sustain such programs in resource-constrained environments. On the other hand, it should be important to assess the sustainability of the interventions co-created some years post-cessation of the intervention.

Additionally, the lack of standardisation of the methods for calculating the compliance rates between countries is considered a limitation, also, the adolescents' unknown reasons for no attendance in the activities. In future research, as a complementary variable in the TIDieR checklist, specifically in the "How well" section, it is recommended to add the reason for adolescent non-attendance to the intervention activities, leading to be able to identify if the non-compliance of the intervention activities will affect outcomes. Finally, the socio-cultural and environmental situation of participants in high schools, which may explain the difference between the duration, frequency, and compliance of interventions, can act as confounders when the effectiveness of SEEDS intervention will be analysed. However, the present study aims to ensure that the co-created interventions in different countries are adapted to the barriers and facilitators identified by the focus groups, and are therefore adapted to the country context. The location of the participating schools in socioeconomically disadvantaged areas limits the generalizability of the findings to schools of higher-income areas. So, future research should consider applying or adapting these interventions in diverse socioeconomic European contexts to test transferability.

In conclusion, the 4 co-created interventions by adolescent ambassadors have some common aspects such as the type of activities (methodology used), who provided the activities, and where and how the activities were implemented. Most of the barriers identified were addressed whereas the facilitators were not enough addressed. So, barriers and facilitators identified should be taken into account when co-creating an intervention to completely adapt the intervention to the real situation. Thus, more effort is needed to completely adapt the intervention to the real interest of adolescents. Future research needs to confirm the SEEDS intervention effect and impact on the desired behaviour.

Abbreviations

CS	Citizen Science
c-RCT	Cluster Randomized Controlled Trial
ECSA	European Citizen Science Association
GR	Greece
HBSC	Health Behaviour in School-aged Children
NL	Netherlands
PA	Physical Activity
PE	Physical Education
SEEDS	Science Engagement to Empower Disadvantaged aDoleScents
STEM	Science Technology Engineering and Mathematics
SES	Socioeconomic Status
SP	Spain
UK	United Kingdom
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1: Additional file 1. pdf: The TIDieR (Template for Intervention Description and Replication) Checklist. The checklist used to describe interventions of the SEEDS project

Supplementary Material 2: Additional file 2. doc: Intervention description of each country. The document describes in depth the interventions implemented in each country of the SEEDS project

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Author contributions

J.Q., E.L., A.W., W.J., Y.M., A.S., C.A.W., D.V., R.S. and L.T. contributed to the design of the study. J.Q., E.L., R.S. and L.T. analysed and interpreted the results and wrote the first draft of the manuscript and A.W., W.J., Y.M., A.S., C.A.W. and D.V. contributed to the manuscript by critical revisions and giving comprehensive feedback on multiple drafts. J.Q., E.L., A.W., W.J., Y.M., A.S., C.A.W., D.V., R.S. and L.T. read and approved the final manuscript.

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Data availability

The data that support the findings of this study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The four pilot countries (Greece, the Netherlands, Spain, and the UK) obtained approval for the study from their corresponding Ethics Committee. Greece: The study was approved by the Bioethics Committee of Harokopio University (ethical approval code: 953/10-3-2021). The Netherlands: The Medical Research Ethics Committee of the Erasmus Medical Centre, Rotterdam, The Netherlands granted permission to execute this study and for publications in a later stage of the study (permission ID: MEC-2021-0396). Spain: The Drug Research Ethics Committee (CEIm) of the Pere Virgili Health Research Institute (Reus, Spain) granted permission to execute this study and for publications in a later stage of the study (n° Ref. CEIM: 085/2021). The UK: The study has been approved by the Sport and Health Sciences Ethics Committee of the University of Exeter, ref. numbers (21-03-24-B-02, 21-07-14-B-04). The SEEDS intervention has adhered to the principles of the Declaration of Helsinki and the International Conference on Harmonization Good Clinical Practice guideline.

Consent for publication

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Competing interests

The authors declare no competing interests.

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