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2.º CICLO

ALIMENTAÇÃO COLETIVA

Impacto de uma intervenção multicomponente na adesão aos refeitórios escolares nos 2º e 3º ciclos do ensino básico de Benavente: um estudo quase-experimental

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Impacto de uma intervenção multicomponente na adesão aos refeitórios escolares no 2º e 3º ciclos do ensino básico de Benavente: um estudo quase-experimental

Impact of a multicomponent intervention on school lunch participation in 2nd and 3rd cycles of basic education in Benavente: quasi-experimental study

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Dissertação de candidatura ao grau de Mestre em Alimentação Coletiva apresentada à Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto

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“Insanity is doing the same thing over and over and expecting different results.”

Albert Einstein

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Resumo

As refeições escolares oferecem uma oportunidade para responder aos problemas atuais do consumo excessivo e insustentável, promovendo dietas saudáveis nas crianças e moldando futuras gerações de consumidores. No entanto, a adesão ao refeitório escolar é baixa, especialmente a partir do 2º ciclo. Mais de metade dos alunos portugueses dos 2.º e 3.º ciclos não frequentam o refeitório escolar, incluindo muitos que têm direito a refeições gratuitas (escalão A) ou a preço reduzido (escalão B).

No ano letivo 2022-23, foi realizado um estudo quase-experimental em duas escolas de 2.º e 3.º ciclos de Benavente, Portugal. A intervenção multicomponente, cocriada com a comunidade escolar, implementou modificações no serviço de alimentação escolar, ambiente do refeitório e no menu. Os principais *outcomes* foram a adesão ao refeitório e satisfação com as refeições escolares, avaliadas pré e pós-intervenção. Adicionalmente, foram recolhidos dados sociodemográficos, socioeconómicos, antropométricos e adesão ao Padrão Alimentar Mediterrânico (PAM). Este estudo teve como objetivo avaliar o impacto de uma intervenção cocriada na adesão e satisfação com a refeição escolar, adesão ao Padrão Alimentar Mediterrânico, Índice de Massa Corporal (IMC) e Razão Perímetro da Cintura Estatura (WHtR). Além disso, estudámos a associação entre a adesão dos alunos ao refeitório e condições sociodemográficas (idade, ano de escolaridade e nacionalidade), estatuto socioeconómico, hábitos alimentares (adesão ao PAM), *outcomes* de saúde (IMC, WHtR) e os fatores que podem influenciar as decisões de adesão. A hipótese colocada é que uma maior adesão ao refeitório escolar terá impacto na prevalência de excesso de peso e obesidade e no comportamento alimentar.

Na fase de pré-intervenção a taxa de adesão ao refeitório escolar foi de 25,3%. Globalmente, 39,1% dos alunos referiram não frequentar a cantina escolar. Morar perto da escola e a qualidade da refeição escolar, que não gostam, foram os principais motivos para a não adesão. Apenas 27% dos alunos com escalão A e B tiveram uma adesão efetiva ao refeitório e a taxa de não adesão neste grupo foi de 31%. A adesão dos alunos ao almoço escolar estava significativamente associada à idade, ano de escolaridade, escalão de ação social e adesão ao PAM. Os alunos mais novos e os alunos de escalão A e B frequentavam com maior assiduidade a cantina. Os nossos resultados evidenciam que uma maior taxa de adesão ao refeitório escolar estava positiva e significativamente associada a uma maior adesão ao PAM, mas não ao IMC e WHtR.

A implementação das propostas apresentadas no processo de cocriação conduziu a um aumento significativo na adesão dos alunos ao refeitório, de 22,1% para 27,4%, representando um aumento de 24,0%. Adicionalmente, a intervenção produziu uma redução significativa da WHtR, mas não do IMC. Isto apoia a capacidade de intervenções cocriadas impactar significativamente a adesão dos alunos à refeição escolar e o estado de saúde dos alunos.

Os resultados do projeto R23 confirmaram a importância da refeição escolar na promoção de dietas saudáveis, sublinhando a necessidade de investir em projetos desenhados com o objetivo de promover a adesão ao refeitório escolar. Este estudo inovador contribuiu para uma melhoria do serviço de alimentação escolar, que oferece não apenas um almoço seguro, nutritivo e sustentável, mas também uma experiência de refeição que os alunos apreciam e desfrutam. Ignorar que a cantina escolar é mais do que um local para comer um almoço saudável prejudicará o sucesso de todas as intervenções políticas.

Palavras-Chave: Adesão ao refeitório escolar; cocriação; Alunos dos 2.º e 3.º ciclos; serviço de alimentação escolar; menu escolar; ambiente do refeitório; Índice de Massa Corporal; Razão Perímetro da Cintura Estatura; Padrão Alimentar Mediterrânico

Abstract

School lunch offers an opportunity to tackle the current problems of over- and unsustainable consumption by promoting sustainable healthy diets in children and shaping healthy future generations of consumers. However, school lunch participation rates remain low, especially among middle and high school students. More than half of the 2nd and 3rd cycles Portuguese students do not participate in the school lunch, including many who are eligible for free or reduced-price meals.

In the school year 2022-23, a quasi-experimental study was conducted in two 2nd and 3rd cycle schools from Benavente, Portugal. The co-created multicomponent intervention changed the school meal service, lunchroom environment, and menu. The primary outcomes were school lunch participation and satisfaction, assessed pre- and post-intervention. Additionally, data on sociodemographic, socioeconomic, anthropometry, and adherence to the Mediterranean Dietary Pattern were assessed at the same time points. This study aimed to evaluate the impact of a co-created intervention on school lunch participation and satisfaction, adherence to the Mediterranean Dietary Pattern (MDP), Body Mass Index (BMI), and Waist-to-Height Ratio (WHtR). Also, we studied the association between students' school lunch participation and sociodemographic (age, grade, and nationality), socioeconomic status, food behavior (adherence to the Mediterranean Dietary Pattern (MDP)), health outcomes (BMI, WHtR), and the factors that may influence participation decisions. We hypothesized that higher school lunch participation will impact overweight and obesity rates and food behavior.

Cross-sectional data was obtained from the R23 quasi-experimental study. The school lunch participation rate was 25.3%. Overall, 39.1% of students reported to not attend the school canteen. Living close to school and the quality of the school lunch, which they do not like, were the main reasons for non-participation. Only 27% of the students eligible for Free or Reduced-Price Meals (FRPM) had an effective adherence to school lunch and the non-participation rate in this group was 31%. Students' school lunch participation was significantly associated with age, grade, eligibility to FRPM, and adherence to Mediterranean Dietary Pattern (MDP). Younger students and students eligible for FRPM went more often to the canteen. Our results suggested that a greater school lunch participation rate was positively and significantly associated with higher adherence to MDP, but not with BMI and WHtR.

The implementation of the co-creator's proposals led to a significant increase in students' school lunch participation, from 22.1% to 27.4%, representing a 24.0% increase. Also, the intervention produced a significant reduction of WHtR, but not in BMI. This supports the ability of co-created intervention to significantly impact students' school lunch participation and health status.

These findings confirmed the importance of school meals in the promotion of sustainable healthy diets stressing the need to invest in projects designed to promote school lunch participation. The innovative R23 project's study protocol contributed to a better school food service, one that offers not only a safe, nutritious, and sustainable lunch but also a lunch experience that students appreciate and enjoy. Ignoring that the school canteen is more than a place to eat a healthy lunch will undermine the success of all the policy interventions.

Keywords: school lunch participation; co-creation; 2nd and 3rd cycles students; school meal service; school menu; lunchroom environment; Body Mass Index; Waist-to-Height Ratio; Mediterranean Dietary Pattern

ÍNDICE


R23

1 INTRODUÇÃO

A escola deve desempenhar um papel ativo na promoção de hábitos alimentares saudáveis[1] e as refeições escolares podem ser uma ferramenta importante para melhorar o comportamento alimentar, a saúde e bem-estar das crianças e jovens e promover ao mesmo tempo a sustentabilidade[2, 3].

A promoção de uma alimentação escolar saudável, segura e nutricionalmente equilibrada tem sido uma prioridade das políticas escolares, nacionais e internacionais, com a publicação de diferentes documentos legislativos[4-8], estratégias[9, 10] e orientações[11]. Atualmente, todas as crianças e jovens em Portugal têm acesso a refeições escolares, saudáveis, equilibradas e a baixo custo, resultado do trabalho desenvolvido ao longo das ultimas décadas[12].

Apesar deste investimento menos de metade dos alunos do 2º e 3º ciclos frequentam o refeitório[13], sendo que em Benavente no ano letivo de 2021/2022 a média situava-se nos 20%. Adicionalmente, o desperdício alimentar é elevado (17%[14] e 18%[15]), indicando uma baixa satisfação com as refeições[16]. Simultaneamente, 32,3% dos adolescentes portugueses tem excesso de peso, destes 8,7% tem obesidade[17].

Este cenário de baixa adesão ao refeitório escolar é comum em vários países desenvolvidos[18-20]. Reconhecendo a existência deste problema, o Referencial para a Educação para a Saúde, no subtema Alimentação em meio escolar, estabelece os seguintes objetivos: "Frequentar assiduamente o refeitório escolar em detrimento de outras possibilidades" e "Valorizar os almoços no refeitório escolar"[21].

Atualmente a alimentação escolar em Portugal é considerada como "*uma medida de ação social escolar, de caráter universal, destinada a todos os alunos, expressa na Lei de Bases do Sistema Educativo, que visa assegurar uma alimentação equilibrada e adequada às suas necessidades.*" [11] e "*O refeitório escolar não é um restaurante*"[11]. Esta visão em que a alimentação escolar é reduzida ao essencial, ação social e espaço educativo, tem como reflexo o abandono da maioria dos alunos, logo após o 2º ciclo. Alguns fatores têm sido apontados para esta diminuição da adesão aos refeitórios escolares, nomeadamente o barulho durante a hora de almoço, lotação do refeitório, ementa servida[14], tempo de espera[22], ambiente do refeitório desagradável[23], não gostar do sabor das refeições[24], refeições com aspeto pouco agradável[14] e estigma associado ao estatuto de ação social escolar[18, 25, 26]. Desta forma, o potencial que as refeições escolares têm na melhoria do estado nutricional dos alunos é desperdiçado.

A questão que se coloca é como reformular a estratégia de promoção da alimentação escolar de forma a aumentar a adesão dos alunos ao refeitório escolar sem comprometer a qualidade nutricional?

Com a transferência de competências prevista no Decreto-Lei n.º 21/2019 para os órgãos municipais, nomeadamente o fornecimento de refeições em refeitórios escolares dos estabelecimentos dos 2.º e 3.º ciclos do ensino básico, as autarquias surgem como um

parceiro que pode dar uma resposta a este problema. Tal como Graça e colegas (2021) referem, as autarquias, pela proximidade que têm com a comunidade escolar, são um parceiro dinâmico e muito ativo[12]. Esta proximidade com a comunidade pode traduzir-se numa mudança da abordagem *top-down*, que tem sido usada habitualmente nas políticas e projetos na área da alimentação escolar, para *bottom-up*. Sabe-se que as intervenções que têm alcançado sucesso na mudança de comportamentos alimentares são aquelas que trabalham vários componentes, como por exemplo, disponibilidade de alimentos saudáveis, sessões de educação na sala de aula, workshops de culinária, envolvimento dos encarregados de educação[2, 27] e inclusão do princípio da participação colaborativa, também conhecida por cocriação[28].

Cocriação é baseado em princípios de *Participatory Action Research* (PAR)[29], uma abordagem "*bottom-up*" reconhecida por ter vantagens significativas na implementação com sucesso de programas de promoção da saúde. Uma característica fundamental da cocriação é a colaboração dos cientistas com os utentes/consumidores e outros *stakeholders* no processo de investigação, desenvolvimento de políticas e programas para produzir resultados que sejam relevantes e respondam às reais necessidades da comunidade. Existem 4 princípios que têm sido descritos como essenciais considerar ao longo do processo de cocriação: 1) cocriação de valor; 2) foco nas experiências de todos os *stakeholders*; 3) interação direta entre todos os *stakeholders* e 4) criação de plataformas que promovam o continuo diálogo entre todos os participantes[30].

Desta forma, reconhecendo a importância que as refeições escolares podem desempenhar na saúde dos jovens, sabendo que a adesão aos refeitórios a partir do 2º ciclo diminui e compreendendo que é necessário intervir em várias áreas (ementas, ambiente do refeitório e serviço de alimentação escolar), foi desenvolvido este projeto que tem na sua essência a implementação de uma intervenção multicomponente cocriada com a comunidade escolar.

2 OBJETIVOS

2.1 OBJETIVOS

O principal objetivo deste estudo foi avaliar o impacto de uma intervenção multicomponente, cocriada com a comunidade escolar, na adesão aos refeitórios escolares em alunos do 2º e 3º ciclos, do Município de Benavente, no ano letivo de 2022/2023.

Pretendeu ainda avaliar o impacto da intervenção nos seguintes objetivos específicos:

i) na satisfação com as refeições escolares;
ii) na adesão ao Padrão Alimentar Mediterrânico;
iii) no Índice de Massa Corporal (IMC) e Razão Perímetro da Cintura Estatura (WHtR);

2.2 PERGUNTAS DE INVESTIGAÇÃO

1. A intervenção multicomponente, cocriada com a comunidade escolar, composta por modificações no menu, serviço e sala de refeições, pode aumentar a adesão ao refeitório escolar e a satisfação dos alunos com as refeições numa escola básica de 2 e 3º ciclos de Benavente?
2. A adesão ao refeitório escolar está associada com uma maior adesão ao Padrão Alimentar Mediterrânico?
3. A adesão ao refeitório escolar está associada a um peso corporal mais saudável?
4. A adesão ao refeitório escolar está associada com o estatuto socioeconómico?

3 ARTIGOS

Do desenvolvimento deste projeto de investigação resultaram três artigos científicos que serão submetidos para publicação após a defesa da dissertação.

Artigo 1 – Co-creating an intervention to increase school lunch participation and satisfaction among 2nd and 3rd cycles students in Portugal: the R23 quasi-experimental study protocol

Autores: Rute Espanhol, Catarina Jacinto Soares, Bruno M.P.M. Oliveira, Duarte Torres e Maria João Gregório

Artigo 2 – Is school lunch participation associated with higher adherence to the Mediterranean Diet and healthier body weight? – a cross-sectional analysis of baseline data from the R23 study

Autores: Rute Espanhol, Catarina Jacinto Soares, Bruno M.P.M. Oliveira, Duarte Torres e Maria João Gregório

Artigo 3 – Impact of a co-created intervention on school lunch participation and satisfaction in 2nd and 3rd cycles students of basic education in Portugal, Benavente: R23 quasi-experimental study

Autores: Rute Espanhol, Catarina Jacinto Soares, Bruno M.P.M. Oliveira, Duarte Torres e Maria João Gregório

3.1 ARTIGO 1

Co-creating an intervention to increase school lunch participation and satisfaction among 2nd and 3rd cycles students in Portugal: the R23 quasi-experimental study protocol

Study protocol

Co-creating an intervention to increase school lunch participation and satisfaction among 2nd and 3rd cycles students in Portugal: the R23 quasi-experimental study protocol

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Abstract: School lunches play an important role in promoting a sustainable, healthy diet for children. However, students' adherence in developed countries is modest. The R23 quasi-experimental study aims to increase school lunch participation and satisfaction among students from 2nd and 3rd cycles (10 to 14 years old) in Portuguese schools. The co-created multicomponent intervention will change the school meal service, lunchroom environment, and menu. The primary outcomes will be school lunch participation and satisfaction, assessed pre- and post-intervention. Additionally, data on sociodemographic, socioeconomic, anthropometry, and adherence to the Mediterranean Dietary Pattern will be assessed at the same time points. We hypothesized that higher school lunch participation will impact overweight and obesity rates and food behavior. The innovative R23 project's study protocol and future results will contribute to a better school food service, one that offers not only a safe, nutritious, and sustainable lunch but also a lunch experience that students appreciate and enjoy.

Keywords: school lunch participation; co-creation; students; school meal service; school menu; lunchroom environment.

1. Introduction

Our food choices affect not only our health but also the health of the planet [1]. Unhealthy diets are the leading risk factor for mortality worldwide [2] and have also a high environmental impact [3-5], being an important contributor to climate change [6]. Changing dietary habits towards a more sustainable healthy diet will require significant action from multiple food system sectors [1]. School lunches have the potential to tackle these challenging problems by establishing healthy eating habits early in life and contributing towards a sustainable healthy diet in adulthood [7-9].

The Portuguese School Lunch Program provides safe, nutritious, and price-reduced lunches, from preschool to secondary students. The school lunch consists of vegetable soup, a main dish (fish, meat, or vegetarian with pasta, rice, or potatoes), salad or cooked vegetables, dessert (fruit or sweet dessert), bread, and tap water [10]. School lunches are subsidized by the Ministry of Education and local authorities. Prices are determined by law yearly but have remained unchanged since 2015 [11]. A school meal costs 1.46 €, half price (0.73 €) or free for students from economically disadvantaged households [11]. The promotion of healthy, sustainable, and nutritionally balanced school meals has been a priority in Portuguese school policies [12], with the publication of different legislative documents [13-17], strategies [18,19], and school food standards [10]. Since 2017, it has been mandatory to offer a vegetarian option [14]. Since 2018, Portuguese school food standards have included Mediterranean and vegetarian recipes to promote more sustainable school meals [10]. Planning and monitoring of school lunches according to national and international nutritional recommendations is facilitated by the free software System of Planning and Evaluation of School Meals (SPARE) developed for Portuguese schools [20].

Despite this investment less than half (42.0%) of the Portuguese students of the 2nd and 3rd cycles attend the school canteen [21], and in Benavente schools, the average is even lower, less than 20%. A recent study on the health of Portuguese adolescents reported that 54.4% of students say that school lunches are their least favorite thing at school [22]. Also, food waste is high (32.3%) [23], indicating low satisfaction with meals [24]. This scenario is also common in other countries [25-27]. Some factors have been pointed out for these low participation rates: noise during lunchtime, canteen capacity, unappealing meals [23], and stigma [25]. Additionally, the food environment of the school canteen can influence students' satisfaction with the meal [28]. Some research even shows that a meal served in a school canteen is less appreciated than when the same meal is served in a restaurant [29], revealing that the negative perception of school meals significantly impacts satisfaction.

School meals' potential to promote students' health is wasted when most students choose not to have lunch in the school canteen. High participation is needed to ensure that school lunches effectively contribute to healthier food habits, well-being, and sustainability. This state-of-the-art calls for innovation in the school food service. Students are the key stakeholders and want their opinions to be included in redesigning the school lunch experience [30-32]. Engagement and empowerment of the school community members (students, teachers, parents, and school staff) are essential for developing a new vision of the school food service that increases participation and satisfaction of students and consequently promotes a healthy diet with positive behavioral and health outcomes. This type of participatory design, also known as co-creation, a bottom-up approach, aims to develop an intervention aligned with students' desires and attitudes, increasing adherence and effectiveness due to the implementation of solutions tailored to their needs and views [33]. The potential of co-creation has been demonstrated in several public health interventions [34-37].

We present a quasi-experimental study protocol aiming to evaluate the impact of an intervention on the school food service co-created with the school community on students' school lunch participation rates and satisfaction. We hypothesize that a school lunchroom, meal service, and menu designed with students, for students, will increase school lunch participation and satisfaction, potentially resulting in a decrease in overweight and obesity rates and an improvement in children's dietary behavior.

2. Methods

2.1. Study design and setting

The study reports a multi-component intervention with a quasi-experimental design and a co-creation participatory methodology, one school year, one intervention, and one control school, 2nd and 3rd cycle schools, from Benavente Municipality, Portugal (Figure

1). This study follows the Guidelines for nonrandomized/quasi-experimental study designs (TREND) [38].

The intervention and control schools are situated in Benavente, Santarém district, in the central part of Portugal, 50 km from Lisbon. Benavente School food service provides safe, high-quality, nutritious meals to about 4500 students. Since 2022, a public contract with a catering company ceased to exist, and currently, the municipality executive directly manages the school food service. Meals are cooked and served directly to students in the control school and transported to the intervention school.

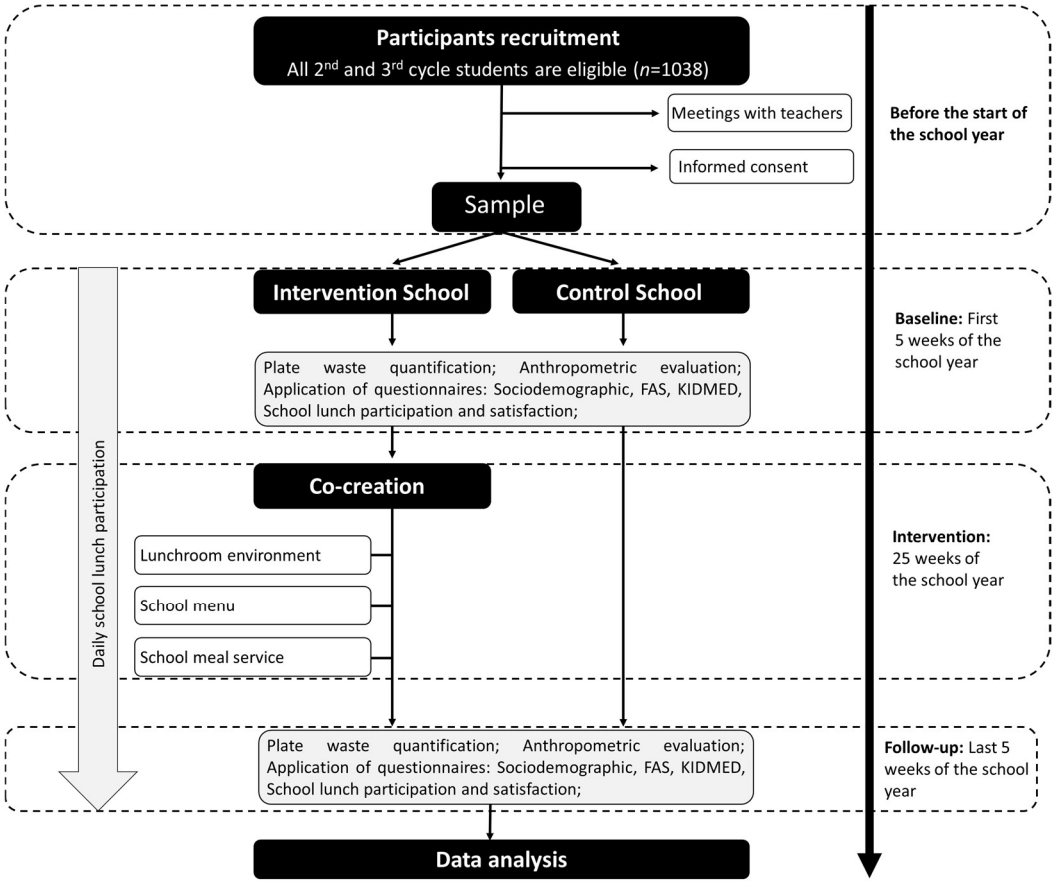

Figure 1. Protocol study flow-chart. FAS, Family Affluence Scale; KIDMED, Mediterranean Diet Quality Index.

2.2. Eligibility and Recruitment

The Benavente Municipality has two schools with 2nd and 3rd cycles education (5th to 8th grades; 10 to 14 years old). All students from the intervention (n = 533) and control (n = 505) schools are eligible to participate in this study if parents' or tutors' consent is obtained.

By convenience, the schools were allocated to control and intervention. This practical decision was made considering the school which required a more urgent investment in the lunchroom. Both educational boards were informed about the study, and their approval and support were guaranteed. The control school will receive a similar intervention in the following year.

To ensure a high participation rate in the study, the research team presented the project in a meeting with head teachers and school directors before the beginning of the school year. All head teachers agreed to inform parents/tutors, in their first parent/teacher meeting, about the study and encourage them to authorize their children's participation. The informed consent was delivered to all parents in this meeting.

2.3. Ethics Approval

The study was reviewed and approved by the Faculty of Food and Nutrition Science of the University of Porto Ethics Committee (118/2023/CEFCNAUP). All participants were informed of the study's goals, and written informed consent was obtained from parents or tutors. Data will be anonymized and kept in a computer protected by password.

2.4. Study Intervention

The R23 project has a participatory design, also known as co-creation, a bottom-up approach. Co-creation refers to the collaborative development of public health interventions considering stakeholders' input (co-creators), scientific evidence, and participatory principles [33,34,39]. In other words, the co-creation process is generated through a democratic engagement of end-users (students) and other relevant stakeholders to design a relevant and appealing intervention, tailored to their specific needs. By empowering students, we expect to increase the success of the R23 project. We aim for a collaborative level of participation, i.e. "*to partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution*" [40].

The intervention of this study will be designed with the active collaboration of elected representatives of the school community: student class delegates, parents' representatives of each class, school council, students' association, parents' association, and municipal councilor. According to Preskill and Jones (2009) [41], motivation is a possible factor to consider in sampling. These co-creators will most likely be more motivated to participate in this project as they already play an active role in the school community. All co-creators will have equal sharing of power. Co-creation framework proposed by Leask *et al* [33] will be used (Table 1).

Table 1. Four stages of co-creation, as proposed by Leask et al [33].

Co-creation stages	
1 - Planning	
What is the purpose of the co-creation?	Using a co-creation methodology to develop and evaluate, with the school community and researchers, an intervention to increase students' school lunch participation and satisfaction in the 2nd and 3rd cycles of basic education in Portugal
Who should be involved?	Elected representatives of the school community: student class delegates, parent representatives, school directors, students' association and parents' association, and local authorities.
2 - Conducting	
What activities can be used during co-creation?	Workshops using interactive techniques from design thinking, i.e.: "How might we...?"; Brainstorming and Affinity mapping.
How to ensure buy-in and commitment?	Elected co-creators.
3 - Evaluating	
How do we know the process and the outcome are valid and effective?	Quasi-experimental study outcomes will include school lunch participation, lunch satisfaction, and plate waste quantification.
4 - Reporting	
How to report the findings?	Use a checklist for reporting initiatives that use co-creation [33].

The co-creation process will start with the statement of the problem of "Low school lunch participation" and the proposal of the following objective: "Design an intervention that revolutionizes the menu, meal service, and lunchroom environment, creating a food service that is attractive to students and parents". To put it simply, we will ask the following question to the co-creators: "*How might we redesign the food service to increase school lunch participation and satisfaction?"*. School meal service, menu, and lunchroom environment are the main components of the intervention that will be developed during the co-creation

process (Figure 2). These three components are considered the most important in customer satisfaction in school lunches [42].

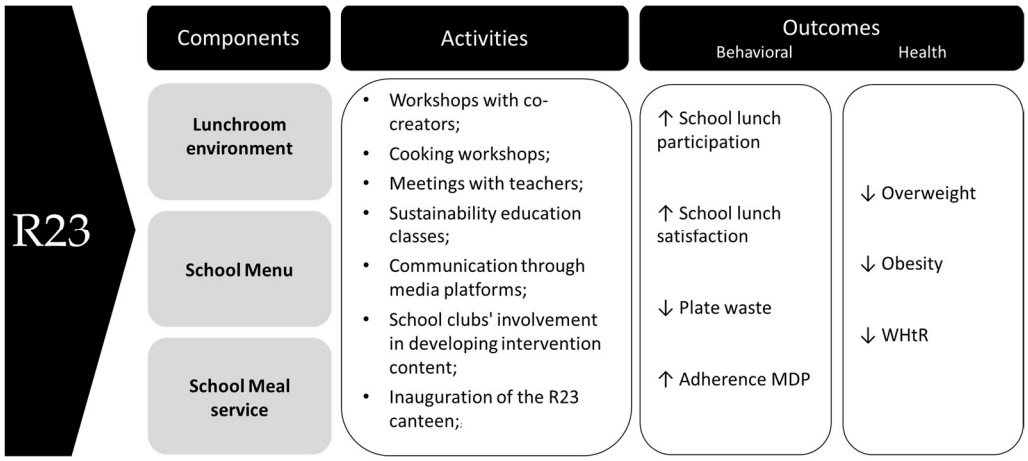

Figure 2. Intervention components, activities, and expected outcomes. MDP, Mediterranean Dietary Pattern; WHtR, Waist-to-Height ratio.

Workshops with co-creators, cooking workshops (co-creators and school community members), sustainability education classes, and meetings with teachers will be some of the specific activities that will be developed during the intervention to collect ideas, recommendations, and solutions to achieve the project's goal. All the proposals will be considered in the redesign. The project will also be communicated via social media and local newspapers to reach all the school community members, especially parents and students.

The end goal will be to design a lunch experience that effectively constitutes a pleasant lunch option for all students and parents.

2.5. Data collection

An overview of all measurements is presented in Table 2.

Table 2. Overview of all measurements taken at the student or school level.

Measurements	Students	School
Daily school lunch participation rate (PR)		X
Plate waste (PW)		X
Eligibility to Free or Reduced Price Meals (FRPM)		X
Anthropometry (BMI; WHtR)	X	
Structured face-to-face questionnaire:		
Sociodemographic (date of birth, gender, nationality, grade)	X	
Socioeconomic status (FAS)	X	
Adherence to the Mediterranean Dietary Pattern (KIDMED)	X	
Average weekly school lunch participation	X	
Factors influencing participation decisions	X	

BMI, Body Mass Index; WHtR, Waist-to-Height ratio; FAS, Family Affluence Scale; KIDMED, Mediterranean Diet Quality Index for children and adolescents.

All measurements will be made at baseline and follow-up, except for "Daily school lunch participation", which will be collected for all school days. Anthropometric evaluation and the application of the structured face-to-face questionnaire will be done in the physical education classes.

2.5.1. Daily school lunch participation

The number of lunches served daily to adults (teachers and school staff), and students will be obtained through the EduBOX SIGA platform (Integrated Management and Learning System), which manages the school lunch booking service. Participation rates will be calculated from the number of served daily school lunches divided by the total number of enrolled students [43].

Participation rates according to subsidized free or reduced-price meals and cycles (2nd and 3rd) will also be obtained from this platform.

2.5.2. Plate waste

One of the indicators to assess meal satisfaction is plate waste (PW) quantification [24,25]. Plate waste corresponds to edible food served that is not eaten. PW quantification will be performed on eight non-consecutive days, at baseline and follow-up.

An aggregate weighing method will be used, which consists of weighing together all the food items left on the plate of each student [44,45]. Plate waste will be separated into different containers, whose weight will be discounted, according to the type of food: soup, main course, and salad.

Plate waste index (1) will be obtained by the ratio between plate waste (kg) and the quantity of food served (kg) [24].

$$\text{PW (\%)} = \text{PW/quantity of food served} \times 100, \quad (1)$$

To quantify the food served, the prepared food will be weighed in the respective containers before distribution begins and when it ends, discounting the weight of the containers.

2.5.3. Anthropometric measurements

Anthropometric measurements will be performed by the main author according to the recommendations [46]. Body mass, height, and waist circumference (WC) will be measured using a portable electronic weight scale (Seca 877, Hamburg, Germany), a portable stadiometer (Seca 217), and a measurement tape (Seca 203), respectively, with the participant barefoot, wearing light clothing.

WHO software Anthroplus will compute BMI-for-age Z-scores [47]. The 2007 WHO BMI-for-age Z-score cut-off points will be used: overweight: > +1 standard deviation (SD); obesity: > +2SD; thinness: < -2SD [48].

Waist-to-Height ratio (WHtR) will be calculated by dividing WC by height and categorized as follows: < 0.5 appropriate, and ≥ 0.5 increased risk of cardiovascular disease [49].

2.5.4. Structured questionnaire

Three previously trained researchers will conduct a face-to-face interviewer-administered questionnaire designed by the authors. The questionnaire has four parts: sociodemographic, socioeconomic status, adherence to the Mediterranean Dietary Pattern, and school lunch participation and reasons to participate.

1. Sociodemographic

Students state their date of birth, nationality, grade, and gender.

2. Socioeconomic status

Students' socioeconomic status will be assessed using the Family Affluence Scale (FAS) [50], from the Health Behavior in School-aged Children survey (HBSC) [51], already used in the Portuguese population [52]. A six-item questionnaire where the participants report whether their family owns a car, whether they have a bedroom, the number of computers that the family owns, how many bathrooms (room with a bath or shower) are in their home, whether their family owns a dishwasher and the number of family vacations abroad during the last 12 months [53]. The items will be summed to give a final

socioeconomic index ranging from 0 to 13 points, with higher scores indicating a better financial level [53].

Eligibility to subsidized free or reduced-price meals (FRPM) will be obtained via the school database. School lunch prices cover three brackets of family income level (A, B, and C) and are determined by law every year. Students in brackets A and B have 100 percent and 50 percent, respectively, of school food expenses covered by public funds. Those in bracket C pay the full price of their meal (€1.46).

3. Adherence to the Mediterranean Dietary Pattern

Participants will be asked about their dietary intake with the sixteen-item Mediterranean Diet Quality Index for children and adolescents (KIDMED) [54], validated for Portuguese adolescents [55]. The final scores of the KIDMED index vary between -4 and 12 points, with higher scores indicating higher adherence to the Mediterranean diet. Participants will be classified into three categories: ≥ 8, high adherence (optimal Mediterranean diet; 4-7, moderate adherence (improvement is needed to adjust intake to Mediterranean patterns), and ≤ 3, low adherence (very low diet quality).

4. School lunch participation

This section of the questionnaire has two parts. The first aims to evaluate the weekly average school lunch participation (0, 1, 2, 3, 4, 5 times/week), and the second to investigate reasons for participation by administering 6 closed questions. Understanding the factors that influence participation decisions can help identify areas for project improvement.

2.6. Statistical analysis

Statistical analysis will be performed using IBM SPSS Statistics for Windows (V.27.0).

Descriptive analysis comprises, depending on the type of variable, mean, standard deviation, relative and absolute frequency. Normality will be tested in cardinal variables in samples higher than 50 using the asymmetry and flatness coefficients criteria, considering that the variable has a normal distribution when these coefficients are between [-2 and 2] [56]. When the sample is less than 50, normality will be tested using the Shapiro-Wilk test.

Student's *t*-test (T), Mann-Whitney (MW), Chi-square (QQ), and Fisher's Exact Test (F) will be used to compare the various variables grouped by intervention and control school at baseline and follow-up (Table 3).

Association between students' school lunch participation and sociodemographic (age, grade), socioeconomic status (FRPM, FAS), food behavior (KIDMED) and anthropometry variables (Body Mass Index (BMI), Waist-to-Height Ratio (WHtR)) will be performed using Pearson's correlation (r^P), between cardinal variables with normal distribution, and Spearman's correlation (r^S) between ordinal or cardinal (non-normal).

Multivariate Analysis of Covariance (MANCOVA; General Linear Model) will be used to evaluate the association between school lunch participation and BMI, WHtR, and KIDMED. Fixed factors (Gender, nationality, and FRPM) and covariates (age, grade, and FAS) will be entered into the MANCOVA models. The final model will be determined using stepwise backward deletion until the adjusted R^2 decreases.

To assess the impact of the intervention in the main variable, school lunch participation rate (PR), Pearson correlation with time will be used.

Two-way Analysis of Covariance (ANCOVA; General Linear Model, univariate) will be used to evaluate the impact of the intervention on plate waste.

ANCOVA for repeated measures (General Linear Model) will be used to evaluate the impact of the intervention between baseline and follow-up, in intervention and control schools, and in the variables BMI, WHtR, and KIDMED. Fixed factors (gender, nationality, and FRPM) and covariates (age, grade, FAS) will be entered into the ANCOVA models. The final model will be determined using stepwise backward deletion until the adjusted R^2 decreases. The effect size will be interpreted using the value of the

partial eta squared (η_p^2) through a qualitative definition of between-subject effects [57]. This criterion identifies the overall adjusted importance of the analyzed variables. The effect size will be classified as small ($\eta_p^2 < 0.030$), medium ($0.030 \leq \eta_p^2 < 0.100$) or large ($\eta_p^2 \geq 0.100$).

Table 3. Characteristics and type of variables under study.

Variables	Classification	Statistic test
Characteristics of the participants		
Age (years)	Cardinal	T-Test
Gender	Nominal	Chi-square test
Grade (5^{th}, 6^{th}, 7^{th} and 8^{th})	Ordinal	Mann-Whitney U test
Nationality	Nominal	Chi-square test
FRPM (A – Free Price Meal; B – Half Price Meal; C – Full Price Meal)	Ordinal	Mann-Whitney U test
FAS score	Cardinal	T-Test
School lunch participation rate (PR) (%)		
PR $_{Adults}$	Cardinal	T-Test
PR $_{Students}$	Cardinal	T-Test
PR $_{2nd\ cycle\ students}$	Cardinal	T-Test
PR $_{3rd\ cycle\ students}$	Cardinal	T-Test
PR $_{FRPM}$	Cardinal	T-Test
Students average school lunch participation		
Average weekly school lunch participation (0x; 1x; 2x; 3x; 4x; 5x/week)	Cardinal	T-Test
Classification of adherence to school lunch (Non-adherence; Partial; Effective adherence)	Ordinal	Mann-Whitney U test
Anthropometry		
BMI-z-score	Cardinal	T-Test
BMI classification	Ordinal	Mann-Whitney U test
WHtR	Cardinal	T-Test
WHtR classification	Nominal	Fisher Exact test
Adherence to MDP		
KIDMED score	Cardinal	T-Test
KIDMED classification	Nominal	Fisher Exact test
Plate waste (PW) (%)		
PW Complete lunch	Cardinal	T-Test
PW Soup	Cardinal	T-Test
PW Main dish	Cardinal	T-Test
PW Vegetables	Cardinal	T-Test

FAS – Family Affluence Scale; FRPM – Free or Reduced Price Meals; BMI – Body Mass Index; WHtR – Waist-to-Height ratio; KIDMED - Mediterranean Diet Quality Index for children and adolescents; MDP – Mediterranean Dietary Pattern.

The confidence level was set at 95% ($p \leq 0.05$).

3. Discussion

It is clear from the low rates of students' school lunch participation in Portugal that providing safe, nutritious, price-reduced, and sustainable school meals is not enough to guarantee students' attendance and satisfaction. While much has been accomplished over

the past decade in Portugal with the promotion of a healthier school food environment, thanks to policies that restricted the presence of unhealthy foods in canteens, vending machines, and cafeterias [17], the impact in the number of served school lunches remains low. If most students do not attend the school canteen [21], considers that canteen food is what they least like in school [22], and those that do attend waste a substantial amount of food [23], the school lunch program is not entirely fulfilling its ambition to promote children´s health, academic success, and wellbeing [10].

The million-dollar question is: how to redesign the school food service to increase students' lunch participation and satisfaction without compromising nutritional adequacy?

Several strategies that can increase school lunch participation have been studied. These include taste tests [58], modified menu options [59], changes to the canteen environment [43], policy restrictions on competitive foods [60], and implementation of nutrition standards [61]. However, a recent systematic review reported that there is limited high-quality evidence on strategies that promote school lunch participation, stressing the need for additional research with rigorous study designs, like quasi-experimental studies with a control group and pre-post measurements [62].

To our knowledge, this is the first quasi-experimental study in Portugal with a co-creation design, a bottom-up school-based intervention, aiming to increase school lunch participation and satisfaction and consequently contribute to healthier food habits and body weight. Several elements make the R23 project unique. First, the R23 has a quasi-experimental design with a control group, baseline, and follow-up measurements. In addition, it uses the TREND guidelines to report results. Second, we will implement a co-created intervention that will make changes in the school meal service, lunchroom environment, and menu and study the impacts on students' participation and satisfaction. A significant strength of the R23 project is the co-creation of the intervention with the school community. Co-creation approaches have been used in nutrition research with successful results [34-37,63]. Third, the high number of children eligible to participate and the many outcomes measured (school lunch participation, health outcomes (BMI, WHtR), and adherence to Mediterranean Dietary Pattern (KIDMED)) are also strengths of this study. We expect to understand possible associations between school lunch participation and socio-demographics (age, grade), socioeconomic status, adherence to the Mediterranean Dietary Pattern (KIDMED), Body Mass Index (BMI), and Waist-to-height ratio (WHtR). Finally, the face-to-face interviewer-administered questionnaire will allow the record of more accurate answers, increase the response rate, and ensure all questions are answered.

Moreover, acknowledging that sustainable development goals (SDG) are directly or indirectly connected to sustainable and healthy food consumption, the R23 project can contribute towards countries' achievement of the SDG, including SDGs 2 (Zero Hunger), 3 (Good Health and Well-being), 4 (Quality Education), 10 (Reduced Inequalities), 12 (Responsible consumption and production) and 13 (Climate action) [64].

There are some limitations to consider. While the randomization of the schools would allow for more robust conclusions, in Benavente's case, this is not possible since one of the schools is much older and in need of improvements in the lunchroom. The lack of randomization can result in selection bias, where the effect of the intervention is confounded with pre-existing differences in the intervention and control schools. However, statistical methods to adjust for potentially confounding effects will be used, like multivariate analysis.

The duration of the study can also be a limitation. A study with a longer duration may be needed to capture the impact of increased school lunch participation on BMI, WHTR, and KIDMED [65]. Additionally, the face-to-face interviewer-administered questionnaire can produce interviewer bias [66].

4. Conclusions

We anticipate that R23 will be an innovative approach to promote school lunches, increase participation, contribute to a decrease in overweight and obesity rates, and promote a sustainable healthy diet in children but also later in life.

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Data Availability Statement: Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

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References

1. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* **2019**, *393*, 447-492.
2. Collaborators, G.B.D.D. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **2019**, *393*, 1958-1972, doi:10.1016/S0140-6736(19)30041-8.
3. Clark, M.; Springmann, M.; Rayner, M.; Scarborough, P.; Hill, J.; Tilman, D.; Macdiarmid, J.I.; Fanzo, J.; Bandy, L.; Harrington, R.A. Estimating the environmental impacts of 57,000 food products. *Proceedings of the National Academy of Sciences* **2022**, *119*.
4. Clark, M.A.; Springmann, M.; Hill, J.; Tilman, D. Multiple health and environmental impacts of foods. *Proc Natl Acad Sci U S A* **2019**, *116*, 23357-23362.
5. IPCC. Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, (in press). **2023**.
6. Rippin, H.L.; Cade, J.E.; Berrang-Ford, L.; Benton, T.G.; Hancock, N.; Greenwood, D.C. Variations in greenhouse gas emissions of individual diets: Associations between the greenhouse gas emissions and nutrient intake in the United Kingdom. *Plos one* **2021**, *16*, e0259418.
7. FAO; WHO. Sustainable healthy diets: guiding principles. **2019**.
8. Truninger, M.; Teixeira, J.; Horta, A.; da Silva, V.A.; Alexandre, S. Schools' health education in Portugal: A case study on children's relations with school meals. *Educação, Sociedade & Culturas* **2013**, 117-133.
9. Oostindjer, M.; Aschemann-Witzel, J.; Wang, Q.; Skuland, S.E.; Egelandsdal, B.; Amdam, G.V.; Schjoll, A.; Pachucki, M.C.; Rozin, P.; Stein, J.; et al. Are school meals a viable and sustainable tool to improve the healthiness and sustainability of

children's diet and food consumption? A cross-national comparative perspective. *Critical Reviews in Food Science and Nutrition* **2017**, *57*, 3942-3958.

10. Direção-Geral da Educação. Circular nº.: 3097/DGE/2018. *Orientações sobre ementas e refeitórios escolares* **2018-08-08**.
11. Ministério da Educação e Ciência - Gabinete do Secretário de Estado do Ensino e da Administração Escolar. Despacho n.º 8452-A/2015. *Diário da República Série-II*, 22 - 27.
12. Graça, P.; Gregório, M.J.; Freitas, M.d.G. A decade of food and nutrition policy in Portugal (2010–2020). *Portuguese Journal of Public Health* **2021**, *38*, 94-118.
13. Assembleia da República. Lei n.º 34/2019. *Diário da República, Série I*, 2544 - 2546.
14. Assembleia da República. Lei n.º 11/2017. *Diário da República, Série I*, 1974 - 1974.
15. Parlamento Europeu e do Conselho. Regulamento (CE) n.° 178/2002. *Jornal Oficial nº L 031*, 0001-0024.
16. Parlamento Europeu e do Conselho. Regulamento (CE) n.° 852/2004. *Jornal Oficial nº L 139*, 0001-0023.
17. Ministério da Educação - Gabinete da Secretária de Estado Adjunta e da Educação. Despacho n.º 8127/2021. *Diário da República Série-II*, 44 - 49.
18. Presidência do Conselho de Ministros. Resolução do Conselho de Ministros n.º 132/2021. *Diário da República Série-I*, 10-46.
19. Finanças, A.I., Educação, Saúde, Economia, Agricultura, Florestas, Desenvolvimento Rural e Mar,. Despacho n.º 11418/2017. *Diário da República Série-II*, 29595-29598.
20. Rocha, A.; Afonso, C.; Santos, M.C.; Morais, C.; Franchini, B.; Chilro, R. System of planning and evaluation of school meals. *Public Health Nutrition* **2014**, *17*, 1264-1270.
21. Madeira, B.M.C. Adesão aos refeitórios escolares no 2º, 3º ciclos e ensino secundário. Instituto Superior de Ciências da Saúde Egas Moniz, 2014.
22. Matos, M.; Guedes, F.; Social, E.A. *A saúde dos adolescentes portugueses em contexto de pandemia - Dados nacionais do estudo HBSC 2022*; 2022.
23. Moreira, P.; Ávila, H.; Correia, M.J. Quantificação do desperdício alimentar em refeitórios escolares: impacto de uma campanha de sensibilização. *Acta Portuguesa de Nutrição* **2021**, *24*, 38-45.
24. Ferreira, M.; Martins, M.L.; Rocha, A. Food waste as an index of foodservice quality. *British Food Journal* **2013**.
25. Fox, M.; Gearan, E.; Cabili, C.; Dotter, D.; Niland, K.; Washburn, L.; Paxton, N.; Olsho, L.; LeClair, L.; Tran, V. Student participation, satisfaction, plate waste, and dietary intakes. *School Nutrition and Meal Cost Study* **2019**, *4*.
26. Cohen, J.F.W.; Hecht, A.A.; McLoughlin, G.M.; Turner, L.; Schwartz, M.B. Universal School Meals and Associations with Student Participation, Attendance, Academic Performance, Diet Quality, Food Security, and Body Mass Index: A Systematic Review. *Nutrients* **2021**, *13*, 911.
27. Cohen, J.F.W.; Hecht, A.A.; Hager, E.R.; Turner, L.; Burkholder, K.; Schwartz, M.B. Strategies to Improve School Meal Consumption: A Systematic Review. *Nutrients* **2021**, *13*, 3520.
28. World Health Organization. Nutrition action in schools: A review of evidence related to the Nutrition-Friendly Schools Initiative. **2020**.
29. Meiselman, H.L.; Johnson, J.L.; Reeve, W.; Crouch, J.E. Demonstrations of the influence of the eating environment on food acceptance. *Appetite* **2000**, *35*, 231-237.
30. Asada, Y.; Hughes, A.G.; Read, M.; Schwartz, M.B.; Chriqui, J.F. High School Students' Recommendations to Improve School Food Environments: Insights From a Critical Stakeholder Group. *J Sch Health* **2017**, *87*, 842-849.
31. Reich, S.; Kay, J.; Lin, G. Nourishing a Partnership to Improve Middle School Lunch Options. *Family & community health* **2015**, *38*, 77-86.
32. Day, R.E.; Sahota, P.; Christian, M.S.; Cocks, K. A qualitative study exploring pupil and school staff perceptions of school meal provision in England. *Br. J. Nutr.* **2015**, *114*, 1504-1514.

33. Leask, C.F.; Sandlund, M.; Skelton, D.A.; Altenburg, T.M.; Cardon, G.; Chinapaw, M.J.M.; De Bourdeaudhuij, I.; Verloigne, M.; Chastin, S.F.M. Framework, principles and recommendations for utilising participatory methodologies in the co-creation and evaluation of public health interventions. *Res Involv Engagem* **2019**, *5*, 2.
34. Tay, B.S.J.; Cox, D.N.; Brinkworth, G.D.; Davis, A.; Edney, S.M.; Gwilt, I.; Ryan, J.C. Co-Design Practices in Diet and Nutrition Research: An Integrative Review. *Nutrients* **2021**, *13*, 3593.
35. Tay, B.S.J.; Edney, S.M.; Brinkworth, G.D.; Cox, D.N.; Wiggins, B.; Davis, A.; Gwilt, I.; Haveman-Nies, A.; Ryan, J.C. Co-design of a digital dietary intervention for adults at risk of type 2 diabetes. *BMC Public Health* **2021**, *21*, 2071.
36. Anselma, M.; Altenburg, T.M.; Emke, H.; van Nassau, F.; Jurg, M.; Ruiter, R.A.C.; Jurkowski, J.M.; Chinapaw, M.J.M. Co-designing obesity prevention interventions together with children: intervention mapping meets youth-led participatory action research. *International Journal of Behavioral Nutrition and Physical Activity* **2019**, *16*, 130.
37. Carins, J.; Bogomolova, S. Co-designing a community-wide approach to encouraging healthier food choices. *Appetite* **2021**, *162*, 105167.
38. Haynes, A.B.; Haukoos, J.S.; Dimick, J.B. TREND Reporting Guidelines for Nonrandomized/Quasi-Experimental Study Designs. *JAMA Surgery* **2021**, *156*, 879-880.
39. Sanders, E.B.-N.; Stappers, P.J. Co-creation and the new landscapes of design. *Co-design* **2008**, *4*, 5-18.
40. Participation, I.A.f.P. IAP2 Public Participation Spectrum. Available online: https://iap2.org.au/resources/spectrum/
41. Preskill, H.; Jones, N. A practical guide for engaging stakeholders in developing evaluation questions. **2009**.
42. Lülfs-Baden, F.; Rojas-Méndez, J.I.; Spiller, A. Young consumers' evaluation of school meals. *Journal of International Food & Agribusiness Marketing* **2008**, *20*, 25-57.
43. Koch, P.A.; Wolf, R.L.; Trent, R.; Guerra, L.A. School Transformation after Redesign of 3 Cafeterias (STARCafé). *Health Behavior and Policy Review* **2020**, *7*, 329-341.
44. Comstock, E.M.; St Pierre, R.G.; Mackiernan, Y.D. Measuring individual plate waste in school lunches. Visual estimation and children's ratings vs. actual weighing of plate waste. *J Am Diet Assoc* **1981**, *79*, 290-296.
45. Liz Martins, M.; Cunha, L.M.; Rodrigues, S.S.; Rocha, A. Determination of plate waste in primary school lunches by weighing and visual estimation methods: a validation study. *Waste Manag* **2014**, *34*, 1362-1368.
46. Stewart, A.; Marfell-Jones, M.; Olds, T.; De Ridder, J. *International Standards for Anthropometric Assessment*; International Society for the Advancement of Kinanthropometry: 2011; Volume 137.
47. World Health Organization. WHO AnthroPlus for personal computers manual: software for assessing growth of the world's children and adolescents. *Geneva: WHO* **2009**.
48. Onis, M.d.; Onyango, A.W.; Borghi, E.; Siyam, A.; Nishida, C.; Siekmann, J. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World health Organization* **2007**, *85*, 660-667.
49. Ashwell, M.; Gibson, S. Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix' based on BMI and waist circumference. *BMJ Open* **2016**, *6*.
50. Currie, C.E.; Elton, R.A.; Todd, J.; Platt, S. Indicators of socioeconomic status for adolescents: the WHO Health Behaviour in School-aged Children Survey. *Health education research* **1997**, *12*, 385-397.
51. Inchley, J.; Currie, D.; Cosma, A.; Samdal, O. Health behaviour in school-aged children (HBSC) study protocol: background, methodology and mandatory items for the 2017/18 survey. St Andrews: CAHRU. **2018**.
52. Botelho Guedes, F.; Cerqueira, A.; Gaspar, S.; Gaspar, T.; Moreno, C.; Gaspar de Matos, M. Family Environment and Portuguese Adolescents: Impact on Quality of Life and Well-Being. *Children (Basel)* **2022**, *9*, 200.
53. Hartley, J.E.K.; Levin, K.; Currie, C. A new version of the HBSC Family Affluence Scale - FAS III: Scottish Qualitative Findings from the International FAS Development Study. *Child Indic Res* **2016**, *9*, 233-245.

54. Serra-Majem, L.; Ribas, L.; Ngo, J.; Ortega, R.M.; García, A.; Pérez-Rodrigo, C.; Aranceta, J. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutr* **2004**, *7*, 931-935.
55. Rei, M.; Severo, M.; Rodrigues, S. Reproducibility and validity of the Mediterranean Diet Quality Index (KIDMED Index) in a sample of Portuguese adolescents. *Br. J. Nutr.* **2021**, *126*, 1737-1748.
56. Field, A. *Discovering statistics using IBM SPSS statistics*; sage: 2009.
57. Cohen, J. *Statistical power analysis for the behavioral sciences*; Academic press: 2013.
58. Pope, L.; Roche, E.; Morgan, C.B.; Kolodinsky, J. Sampling tomorrow's lunch today: Examining the effect of sampling a vegetable-focused entrée on school lunch participation, a pilot study. *Preventive Medicine Reports* **2018**, *12*, 152-157.
59. Rafferty, K.; Zipay, D.; Patey, C.; Meyer, J. Milk enhancements improve milk consumption and increase meal participation in the NSLP: the School Milk Pilot Test. *Journal of Child Nutrition and Management* **2009**, *33*.
60. Boehm, R.; Read, M.; Henderson, K.E.; Schwartz, M.B. Removing competitive foods v. nudging and marketing school meals: a pilot study in high-school cafeterias. *Public Health Nutrition* **2020**, *23*, 366-373.
61. Cohen, J.F.W.; Gorski, M.T.; Hoffman, J.A.; Rosenfeld, L.; Chaffee, R.; Smith, L.; Catalano, P.J.; Rimm, E.B. Healthier Standards for School Meals and Snacks: Impact on School Food Revenues and Lunch Participation Rates. *American Journal of Preventive Medicine* **2016**, *51*, 485-492.
62. Hecht, A.A.; Olarte, D.A.; McLoughlin, G.M.; Cohen, J.F.W. Strategies to Increase Student Participation in School Meals in the United States: A Systematic Review. *J Acad Nutr Diet* **2023**.
63. Driessen-Willems, M.D.; Bartelink, N.H.M.; Bessems, K.; Kremers, S.P.J.; Kintzen, C.; van Assema, P. Co-Creation Approach with Action-Oriented Research Methods to Strengthen "Krachtvoer"; A School-Based Programme to Enhance Healthy Nutrition in Adolescents. *Int J Environ Res Public Health* **2021**, *18*.
64. UN. Res/70/1 Transforming Our World: The 2030 Agenda for Sustainable Development, 21 October 2015. **2015**.
65. Chaudhary, A.; Sudzina, F.; Mikkelsen, B.E. Promoting Healthy Eating among Young People—A Review of the Evidence of the Impact of School-Based Interventions. *Nutrients* **2020**, *12*, 2894.
66. Cook, C. Mode of administration bias. *J Man Manip Ther* **2010**, *18*, 61-63.

3.2 ARTIGO 2

Is school lunch participation associated with higher adherence to the Mediterranean Diet and healthier body weight? – a cross-sectional analysis of baseline data from the R23 study

Article

Is school lunch participation associated with higher adherence to the Mediterranean Diet and healthier body weight? – a cross-sectional analysis of baseline data from the R23 study

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Abstract: Considering the importance of school meals in promoting sustainable healthy diets, this study aimed to identify which factors influence the choice to lunch in the school canteen and associations with sociodemographic, socioeconomic status, anthropometry, and adherence to Mediterranean Dietary Pattern (MDP). Cross-sectional data was obtained from the R23 quasi-experimental study. The school lunch participation rate was 25.3%. Overall, 39.1% of students reported not to attend the school canteen. Living close to school and the quality of the school lunch, which they do not like, were the main reasons for non-participation. Only 27% of the students eligible for Free or Reduced-Price Meals (FRPM) had an effective adherence to school lunch and the non-participation rate in this group was 31%. Students' school lunch participation was significantly associated with age, grade, eligibility to FRPM, and adherence to MDP. Younger students and students eligible for FRPM went more often to the canteen. Our results suggested that a greater school lunch participation rate was positively and significantly associated with higher adherence to MDP, but not with BMI and WHtR. These findings confirmed the importance of school meals in promoting sustainable healthy diets stressing the need to invest in projects designed to promote school lunch participation.

Keywords: school lunch participation; school lunch satisfaction; Mediterranean Dietary Pattern; body mass index; waist-to-height ratio; socioeconomic status

1. Introduction

The prevalence of overweight and obesity has risen dramatically in the last decades. According to data from the Portuguese National Food and Physical Activity Survey, 23.6% and 8.7% of adolescents live with overweight and obesity, respectively [1]. Childhood obesity in Portugal is higher than the average of the Organization for Economic Cooperation and Development countries (OECD) [2]. Accordingly, about half of Portuguese adolescents have an unhealthy dietary pattern, with low consumption of fruits,

vegetables, and pulses [3]. Inadequate nutrition is one of the leading preventable causes of non-communicable chronic diseases (NCDs), loss of quality of life, and premature mortality in Portugal [4,5].

School meals have the potential to contribute to a healthier diet and can thus influence children's weight and nutritional status [6]. Promotion of school lunch participation might be an important action against the childhood obesity epidemic [7]. Students who participate in school lunch programs have been found to have better nutrient intake [8,9], higher overall diet quality [10,11], reduced risk of obesity [12], and better academic results [13], than those who do not participate.

In Portugal, the National School Lunch Program has undergone several changes in the last decades to fulfill new nutritional and public health concerns [14]. At the beginning of the 20th century, the initial aim was to improve food security by preventing children's undernutrition. Nowadays, school lunch focuses on food quality and promoting healthy and sustainable food habits [14] as a strategy to reduce children's overweight and obesity. Nevertheless, school meals are still an important safety net for many students from low-income families mitigating disparities in access to nutritious meals [15].

School lunches in Portugal consist of vegetable soup, a main course (meat, fish, or vegetarian option, served with rice, pasta, or potatoes), vegetables (salad or cooked vegetables), dessert (fresh fruit or sweetened dessert once a week), bread, and tap water. Portuguese school food standards establish what types of food should be served and how often, portion sizes according to age group, limit total calories to 30-35%, guidance on food allergies, and propose several vegetarian and Mediterranean recipes [16].

The challenge in Portugal, as in other developed countries, is the decreasing school lunch participation rates from the 2nd cycle onwards [11,17,18]. More than half of the Portuguese students do not participate in the school lunch, including many who are eligible for free or reduced-price meals (FRPM) [19]. School lunch participation may be influenced by multiple factors, like stigma associated with being low-income student relying on the school meal program [7,20], hunger [17], quality and variety of food offered [21], food appearance and taste [22], length of lunch period [21], time waiting in line [21], price [18], food environment near schools, such as fast-food restaurants and grocery stores [23] and preference to eat a lunch at or from home [17]. For the Portuguese school lunch program to accomplish its goals achieving higher school lunch participation levels is crucial.

This paper aims to describe the baseline results of the R23 project. One of the objectives of this study was to assess school lunch participation rates and gain a better understanding of the factors that influence participation decisions. Also, the project aimed to study the associations between school lunch participation and sociodemographic (age, nationality, grade), socioeconomic status, food behavior (adherence to the Mediterranean Dietary Pattern (KIDMED)), and health outcomes (Body Mass Index (BMI), Waist-to-Height Ratio (WHtR)).

2. Materials and Methods

2.1. Study design and sample

The current study is part of the "Impact of a co-created intervention on school lunch participation and satisfaction in 2nd and 3rd cycles of basic education in Portugal, Benavente: R23 quasi-experimental study", carried out in two Portuguese schools from Benavente, in the Santarém district, aiming to increase school lunch participation and satisfaction in adolescents.

The R23 quasi-experimental study protocol is detailed elsewhere (Artigo 1). Briefly, this cross-sectional study includes baseline data collected at the beginning of the 2022/2023 school year.

The study was reviewed and approved by the Faculty of Food and Nutrition Science of the University of Porto Ethics Committee (118/2023/CEFCNAUP). All participants were informed of the study's goals, and written informed consent was obtained from parents or guardians.

2.2. Measurements

Data collection was made at the student level and school level. Using a face-to-face structured questionnaire delivered by trained research assistants, students' sociodemographic data (age, gender, nationality), socioeconomic status, Mediterranean Diet Quality Index for children and adolescents, and school lunch participation were assessed. Daily school lunch participation rates were obtained via the school lunch booking service. Anthropometric measurements were performed on all students with a consent form (Figure 1).

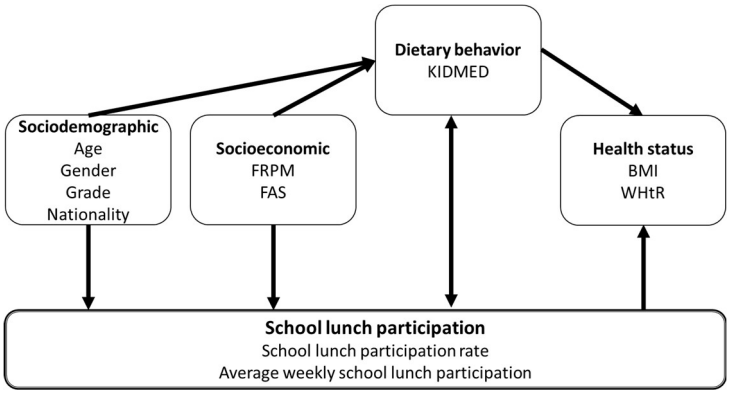

Figure 1. Variables measured in the study. FAS, Family Affluence Scale. FRPM, Free or Reduced Price Meals. KIDMED, Mediterranean Diet Quality Index for Children and Adolescents. BMI, Body Mass Index, WHtR, Waist-to-Height Ratio.

Sociodemographic

Date of birth, nationality, grade, and gender were collected for each student.

Socioeconomic status (FAS and FRPM)

Socioeconomic status was evaluated through two different indicators: using information from eligibility to subsidize free or reduced-price meals (FRPM), obtained via the school administrative database, and using a scale that indirectly determines family wealth.

School lunch prices cover three brackets of family income level (A, B, and C) and are determined by law [24]. Students in brackets A and B have 100 percent and 50 percent, of school food expenses covered by public funds, respectively. Those in bracket C pay the full price of their meal, currently set at €1.46.

The Family Affluence Scale (FAS) used in the protocol of the international study Health Behaviour in School-aged Children (HBSC) [25] is a way of assessing family wealth solving the usual problem of lack of answers when used in questionnaires parents' occupation and education level [26]. The FAS includes items that reflect a family's material resources, consumption pattern, and purchasing power [26]. The FAS score was calculated for each student based on the answers to 6 questions, on a scale ranging from 0 to 13 points, where higher values indicate a higher economic level.

Anthropometry (BMI and WHtR)

Anthropometric measurements were performed according to recommendations [27], in physical education classes. Weight, height, and waist circumference (WC) were

measured using a portable electronic weight scale (Seca 877, Hamburg, Germany), a portable stadiometer (Seca 217), and a measurement tape (Seca 203), respectively, with the participant barefoot, wearing light clothing.

Body mass index (BMI)-for-age *Z*-scores were calculated using the World Health Organization (WHO) software Anthroplus [28]. The WHO cut-off points were used [29].

Waist-to-Height ratio (WHtR) was calculated by dividing WC by height and categorized as follows: < 0.5 appropriate, and ≥ 0.5 increased risk of cardiovascular disease [30,31].

Mediterranean Diet Quality Index for children and adolescents (KIDMED)

To assess adherence to the Mediterranean Dietary Pattern (MDP) the Mediterranean Diet Quality Index for Children and Adolescents (KIDMED) questionnaire was applied [32]. The KIDMED score was calculated from sixteen yes/no questions, validated for Portuguese adolescents [33]. The final scores of the KIDMED index varied between -4 and 12 points, with higher scores indicating higher adherence to the MDP. Students were classified into three categories: ≥ 8, high adherence (optimal Mediterranean diet; 4-7, moderate adherence (improvement is needed to adjust intake to Mediterranean patterns), and ≤ 3, low adherence (very low diet quality).

School lunch participation

Adherence to the school canteen was studied in two ways, through the number of meals served in each school canteen and through the answers obtained in the questionnaire applied to students.

The number of meals served per day, for 25 days, was obtained through the EduBOX SIGA platform (Integrated Management and Learning System), which manages the school meal booking service. The daily participation rates (PR) were calculated according to the following formulas:

$$PR_{Adults}\ (\%) = \text{No. of meals served to adults} / \text{No. Adults working in school} \times 100 \quad (1)$$

$$PR_{Students}\ (\%) = \text{No. of meals served to students} / \text{No. of enrolled students} \times 100 \quad (2)$$

$$PR_{FRPM}\ (\%) = \text{No. of meals served to FRPM students} / \text{No. of eligible FRPM students} \times 100 \quad (3)$$

The total number of enrolled students was corrected weekly as students entered and left throughout the school year. Also, the number of students eligible for FPRM was corrected weekly because this status can change throughout the school year.

With the question "On average, how many days a week do you have lunch in the canteen?" another variable was obtained, whose responses were categorized according to Sturion *et al.* [34] as: non-adherence (nonparticipation); partial adherence (participation one to three times a week) and effective adherence (participation four to five times a week).

Reasons for participation and nonparticipation were evaluated in the questionnaire with the application of 6 closed questions.

2.3. Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, for Windows (V.27.0). Descriptives are presented as the mean and standard deviation (SD) for continuous variables and counts and percentages for categorical variables.

To evaluate the differences between the two groups, independent samples *t*-test, Mann–Whitney tests, and chi-square tests were performed in continuous variables with normal distribution, without normal distribution, and nominal variables, respectively.

The normality of continuous variables was assessed using the Shapiro-Wilk test ($n < 50$) or using the criteria of asymmetry and flatness coefficients ($n > 50$), depending on sample size.

Pearson or Spearman correlation coefficients were used to assess associations between school lunch participation and age, grade, FAS, FRPM, BMI, WHtR, and KIDMED. Strength of the correlation is very weak if $|r| < 0,25$, weak if $0,25 \leq |r| < 0,5$, moderated if $0,5 \leq |r| < 0,75$, strong if $0,75 \leq |r| < 0,9$ or very strong if $0,9 \leq |r| \leq 1$.

Multivariate Analysis of Covariance (MANCOVA, General Linear Model, multivariate) was used to evaluate the association between the dependent variables, BMI, WHtR, KIDMED, and the independent variable school lunch participation. Fixed factors included gender, nationality, FRPM, and grade. Covariates were age and FAS. Associations between BMI, WHtR, and KIDMED and the covariates were also analyzed. The final model was determined using stepwise backward deletion until the adjusted R^2 decreased.

The level of significance was set at $p < 0.05$.

3. Results

Of the total of 1038 students enrolled in these two schools, all invited to participate, 232 students were not evaluated, due to refusal by the parent ($n = 115$), non-return of informed consent ($n = 86$), or absence in the evaluation day ($n = 31$). The student participation rate for the baseline data collection of this study was 77.6%. From this initial total sample, 806 students (377 girls and 429 boys), aged 10 – 16 years (mean age of 11.8 ± 1,2 years) provided complete data on the variables of interest of the present report. They, therefore, were included in the study (Table 1).

Table 1. Sociodemographic and socioeconomic characteristics of the participants.

	Intervention school ($n = 425$)	**Control school** ($n = 381$)	**Total** ($n = 806$)	p
Age, mean years (SD)	12.1 (1.3)	11.5 (1.1)	11.8 (1.2)	**<0.001^{T*}**
Gender, *n* (%)				
Female	204 (48.0%)	173 (4.4%)	377 (46.8%)	0.461^{F}
Male	221 (52.0%)	208 48.5%)	429 (53.2%)	
Grade, *n* (%)				
5th Grade	117 (27.5%)	147 (38.6%)	264 (32.8%)	
6th Grade	122 (28.7%)	172 45.1%)	294 (36.5%)	**<0.001^{MW*}**
7th Grade	92 (21.6%)	35 (9.2%)	127 (15.8%)	
8th Grade	94 (22.1%)	27 (7.1%)	121 (15.0%)	
Portuguese nationality, *n* (%)	386 (90.8%)	329 (86.4%)	715 (88.7%)	**0.003^{Q*}**
FAS, mean (SD)	7.4 (2.2)	7.2 (2.0)	7.3 (2.0)	0.181^{T}
Students eligible for FRPM, *n* (%)				
A - Free Price Meal	74 (17.4%)	59 (15.5%)	133 (16.5%)	
B - Half Price Meal	64 (15.1%)	71 (18.6%)	135 (16.7%)	0.828^{MW}
C - Full Price Meal	287 (67.5%)	251 (65.9%)	538 (66.8%)	

* Values of $p < 0.05$ indicate that the schools differ about the analyzed variables; FAS – Family Affluence Scale; FRPM – Free or Reduced Price Meals; MW - Mann-Whitney U test; T – *t*-test; Q – Chi-square test; F – Fisher Exact test.

The mean ages were 12.1 ± 1.3 years in the intervention school and 11.5 ± 1.1 years in the control school. There were significant differences between schools regarding age, number of students with Portuguese nationality, and number of students in each grade. The intervention school has more Portuguese students and a homogeneous distribution of students in each grade. The control school has more students in 5th and 6th grades (2nd cycle) than in 7th and 8th grades (3rd cycle) impacting the average age.

No significant differences between participants in gender, eligibility to FRPM, and FAS were found at baseline, between schools (Table 1).

One-third of the students from both schools are entitled to FRPM (33.2%; n = 268), 16.5% (n = 133) were entitled to free and 16.7% (n = 135) to reduced-price meals. A weak, significant positive correlation exists between FAS and FRPM (r^S=0.349; p < 0.001).

3.1. School lunch participation and factors that influence participation decisions

School lunch participation rates were very low in both schools for students (25.3%) and adults (professors and school staff; 2.1%), with significant differences between schools. The control school had a higher adult lunch participation rate (3.2%) than the intervention school (1.1%). Likewise, students' participation rate was significantly different, with the control school (28.5%) having a higher school lunch participation rate than the intervention (22.1%). The participation rate was higher in 2nd cycle (26.61%) than 3rd cycle students (19.32%) (Table 2).

Table 2. Average school lunch participation rate, for adults and students, according to school lunch booking system.

	Intervention school (n = 25)	**Control school** (n = 25)	**Total** (n = 25)	p
Adults				
Participation rate, % (SD)	1.1% (1.1)	3.2% (2.4)	2.1% (2.3)	**<0.001^{W*}**
Students				
Participation rate, % (SD)				
All students	22.1% (2.8)	28.5% (7.3)	25.3% (7.0)	**<0.001^{T*}**
2nd cycle	24.9% (3.0)	28.3% (9.9)	26.6% (8.9)	0.221^{W}
3rd cycle	18.6% (3.8)	20.1% (5.4)	19.3% (5.4)	0.165^{T}
A - Free Price Meals	46.8% (6.6)	41.8% (9.2)	44.3% (11.7)	**0.044^{T*}**
B - Reduced Price Meals	25.6% (4.9)	27.1% (8.4)	26.3% (6.2)	0.216^{T}
C - Full Price Meals	16.2% (2.4)	25.9% (7.1)	21.1% (6.9)	**<0.001^{T*}**

* Values of $p < 0.05$ indicate that the schools differ about the analyzed variables; W – Wilcoxon test; T – t-test.

The participation rate of students entitled to free-price meals was significantly higher in the intervention (46.8%) than in the control school (41.8%). On average, less than half of the students (44.3%) who benefit from free meals had lunch in the school canteen daily. An even inferior percentage was observed for reduced-price meals, with only 26.3% of students with this benefit having lunch at school (Table 2).

Table 3. Average weekly school lunch participation reported by students in the questionnaire.

	Intervention school (n = 425)	**Control school** (n = 381)	**Total** (n = 806)	***t-test*** p
No adherence, n (%)	**231 (54.4%)**	**84 (22.0%)**	**315 (39.1%)**	
Partial adherence, n (%)	**127 (29.9%)**	**177 (46.4%)**	**304 (37.8%)**	
1 time/week,	53 (12.5%)	132 (34.6%)	185 (23.0%)	
2 times/week	28 (6.6%)	37 (9.7%)	65 (8.1%)	
3 times/week	46 (10.8%)	8 (2.1%)	54 (6.7)	**<0.001***
Effective adherence, n (%)	**67 (15.7%)**	**120 (31.5%)**	**177 (23.2%)**	
4 times/week	9 (2.1%)	5 (1.3%)	14 (1.7%)	
5 times/week	58 (13.6%)	115 (30.2%)	173 (21.5)	

* Values of $p < 0.05$ indicate that the schools differ about the analyzed variables.

Significant differences existed between schools in the average weekly school lunch participation reported by students in the questionnaire. Overall, 39.1% (n = 315) of students reported never attending the school canteen. This percentage was much higher in the intervention (54.4%) than in the control school (22.0%). At the other extreme, the control school had more students with effective adherence (31.5%) than the intervention school (15.7%). Overall, most students had a partial adherence to the canteen (37.8%), when compared to effective adherence (23.2%) (Table 3).

The main reasons stated by students to participate in school lunch (n=491; 60.9%) were the schedule (60.9%) when they only had one lunch hour and the fact that they had no one at home to cook lunch (17.1%). Some students mentioned lunch quality as a determinant factor in choosing school lunch (7.6%). Students' main reason for not having lunch every day in the canteen was that they prefer to have lunch at home when they do not have classes in the morning or afternoon (87.8%). For most students, the main alternative to the canteen was having lunch at home (83.2%).

The main reasons given by the students for not having lunch at school (n=315; 39.1%) were the fact that they live close by (41.3%) and the quality of the meals (34.6%), which they did not like. These students chose to have lunch at home (69.5%), with family members (14.3%), take their lunch box (10.2%), or have lunch at nearby restaurants (4.8%).

3.2. Anthropometry and Adherence to the Mediterranean Dietary Pattern

Schools have no significant differences in BMI z-scores, WHtR, and KIDMED scores. Overall, overweight was 23.6%, and obesity was 16.1%. About 13.8% of students had an increased risk of cardiovascular disease (WHtR > 0.5) (Table 4).

Table 4. Percentage of students according to Body Mass Index classes, WHtR ≥ 0.5 and KIDMED.

	Intervention school (n = 424)	**Control school** (n = 381)	**Total** (n = 805)	***t-test*** ***p***
BMI, *n* (%)				
Thinness	11 (2.6%)	9 (2.4%)	20 (2.5%)	
Normal body weight	239 (56.4%)	226 (59.3%)	465 (57.8%)	0.993
Overweight	100 (23.6%)	90 (23.6%)	190 (23.6%)	
Obesity	74 (17.5%)	56 (14.7%)	130 (16.1%)	
WHtR, *n* (%)				
≥ 0.5	67 (15.8%)	44 (11.5%)	111 (13.8%)	0.113
KIDMED, mean score (SD)	6.1 (2.4)	6.2 (2.4)	6.2 (2.4)	0.306
Low adherence, *n* (%)	64 (15.1%)	48 (12.6%)	112 (13.9%)	
Moderate adherence, *n* (%)	240 (56.5%)	221 (58.2%)	461 (57.3%)	
High adherence, *n* (%)	121 (28.5%)	111 (29.2%)	232 (28.8%)	

* Values of $p < 0.05$ indicate that the schools differ about the analyzed variables; BMI – Body Mass Index; WHtR – Waist-to-Height ratio; KIDMED - Mediterranean Diet Quality Index for Children and Adolescents.

The average KIDMED Index score was 6.2 ± 2.4 points, 28.8% of students had high, 57.3% moderate, and 13.9% had low adherence to MDP (Table 4).

There was a statistically significant negative association between the KIDMED Index score and BMI Z score (r^P= -0.083; p=0.019) and WHtR (r^P= -0.116; p<0.001). The higher the BMI and the WHtR, the lower the adherence to MDP.

Most students used olive oil (97.4%), had breakfast every day (85.5%), ate pasta or rice almost every day (80.0%), ate dairy products for breakfast (75.3%), and ate a piece of fruit or drank fresh juice every day (68.8%). It is important to point out the low percentage of students who ate a second piece of fruit every day (31.1%) and ate fresh or cooked vegetables more than once a day (23.9%) (Table 5).

Table 5. Mediterranean Diet Quality Index for Children and Adolescents (KIDMED Index) answers.

KIDMED index questions	Intervention school (n = 425) Yes, n (%)	Control school (n = 380) Yes, n (%)	Total (n = 805) Yes, n (%)	Fisher's Exact Test p
1 - Do you eat a piece of fruit or drink fresh fruit juice every day?	287 (67.5%)	267 (70.3%)	554 (68.8%)	0.446
2 - Do you eat a second piece of fruit every day?	123 (28.9%)	127 (33.4%)	250 (31.1%)	0.195
3 - Do you eat fresh vegetables (for example: salads) or cooked vegetables (for example: soup) regularly, once a day?	244 (57.4%)	214 (56.3%)	458 (56.9%)	0.776
4 - Do you eat fresh or cooked vegetables more than once a day?	98 (23.1%)	94 (24.7%)	192 (23.9%)	0.619
5 - Do you eat fish/seafood (e.g., hake, sardines, octopus, shrimp) regularly (at least 2 to 3 times a week)?	263 (61.9%)	263 (69.2%)	526 (65.3%)	**0.032***
6 - Do you go, once or more a week, to fast-food restaurants like hamburger places?	41 (9.6%)	42 (11.1%)	83 (10.3%)	0.562
7 - Do you like and eat pulses (e.g., beans, peas, chickpeas, broad beans, lentils) more than once a week?	236 (55.5%)	201 (52.9%)	437 (54.3%)	0.479
8 - Do you eat pasta or rice almost every day (5 days or more a week)?	355 (83.5%)	289 (76.1%)	644 (80.0%)	**0.010***
9 - Do you eat cereal or cereal products (e.g., oats, bread) for breakfast?	188 (44.2%)	192 (50.5%)	380 (47.2%)	0.074
10 - Do you eat nuts (e.g., walnuts, almonds, hazelnuts) regularly (at least 2–3 times a week)?	84 (19.8%)	86 (22.6%)	170 (21.1%)	0.342
11 - Do you use olive oil at home?	416 (97.9%)	368 (96.8%)	784 (97.4%)	0.383
12 - Do you take breakfast every day?	356 (83.8%)	332 (87.4%)	688 (85.5%)	0.161
13 - Do you eat dairy products (yogurt, milk, cheese) for breakfast?	320 (75.3%)	286 (75.3%)	606 (75.3%)	1.000
14 - Do you eat commercially baked goods or pastries (e.g., cookies, cakes, croissants, donuts) for breakfast?	79 (18.6%)	75 (19.7%)	154 (19.1%)	0.720
15 - Do you eat 2 yogurts and/or 2 slices of cheese a day?	204 (48.0%)	172 (45.3%)	376 (46.7%)	0.479
16 - Do you eat sweets and candies several times a day (e.g., chocolates, gums, sweets)?	49 (11.5%)	22 (5.8%)	71 (8.8%)	**0.004***

* Values of $p < 0.05$ indicate that the schools differ about the analyzed variables.

3.3. School lunch participation and its association with socioeconomic status, MDP, BMI, and WHtR

Using average weekly school lunch participation data reported by students in the face-to-face questionnaire we tested possible associations with the following variables: gender, age, grade, FAS, eligibility to FRPM, BMI, WHtR, and KIDMED (Table 6).

There was a negative, weak, but significant correlation between age (r^S= -0.246; p<0.001), grade level (r^S= -0.271; p<0.001), and school lunch participation. Students in higher education years and older went to the school canteen less often. There is also a negative, weak correlation between the eligibility for FRPM and school lunch participation (r^S= -0.130; p<0.001). Students entitled to FRPM went more often to the canteen.

In this study, 268 students are eligible for FRPM. It is important to notice that 31% (n = 83) of these students reported never having lunch in the school canteen (Table 6).

Table 6. Percentage of students by participation status in each variable. Correlation between school lunch participation classes and age, grade, FAS, Students eligible for FRPM, BMI-for-age Z-score, WHtR, and KIDMED.

	Average weekly school lunch participation				
	No adherence 0 times/week (n = 315)	**Partial adherence** 1 to 3 times/week (n = 304)	**Effective adherence** 4 to 5 times/week (n = 187)	p	**Correlation coefficient**
Gender, n (%)					
Female	153 (48.6%)	141 (46.4%)	83 (44.4%)	0.407^{MW}	-
Male	162 (51.4%)	163 (53.6%)	104 (55.6%)		
Age, mean years (SD)	12.14 (1.26)	11.70 (1.18)	11.38 (1.07)	**<0.001***	**-0.246^{S}***
Grade, n (%)					
Grade 5	61 (19.4%)	112 (36.8%)	91 (48.7%)		
Grade 6	128 (40.6%)	99 (32.6%)	67 (35.8%)	**<0.001***	**-0.271^{S}***
Grade 7	55 (17.5%)	52 (17.1%)	20 (10.7%)		
Grade 8	71 (22.5%)	41 (13.5%)	9 (4.8%)		
FAS, mean (SD)	7.4 (2.0)	7.4 (2.0)	7.1 (2.3)	0.282	-0.038
Students eligible for FRPM, n (%)					
A - Free Price Meal	33 (10.5%)	52 (17.1%)	48 (25.7%)		
B - Half Price Meal	50 (15.9%)	61 (20.1%)	24 (12.8%)	**<0.001***	**-0.130^{S}***
C - Full Price Meal	232 (73.7%)	191 (62.8%)	115 (61.5%)		
BMI-for-age Z-score, n (%)					
Thinness	6 (1.9%)	10 (3.3%)	4 (2.1%)		
Normal body weight	189 (60.2%)	171 (56.3%)	105 (56.1%)	0.905	0.004
Overweight	66 (21.0%)	76 (25.0%)	48 (25.7%)		
Obesity	53 (16.9%)	47 (15.5%)	30 (16.0%)		
WHtR, n (%) ≥ 0.5	49 (15.6%)	40 (13.2%)	22 (11.8%)	0.595	0.019
KIDMED, n (%)					
Low adherence	55 (17.5%)	39 (12.8%)	18 (9.7%)		
Moderate adherence	175 (55.6%)	170 (55.9%)	116 (62.4%)	**0.018***	**0.083^{S}***
High adherence	85 (27.0%)	95 (31.3%)	52 28.0%)		

* Values of $p < 0.05$ indicate that there is a significant correlation between variables; FRPM – Free or Reduced Price Meals; FAS – Family Affluence Scale; BMI – Body Mass Index; WHtR – Waist-to-Height ratio; KIDMED - Mediterranean Diet Quality Index; S - Spearman correlation; MW – Mann Whitney test.

There was a positive correlation between school lunch participation (categorized as non-adherence, partial adherence, and effective adherence) and the KIDMED (r^S= 0.083; p=0.018). Greater school lunch participation, and greater adherence to the MDP. After adjustment for gender, nationality, and FAS, an increase of 1 day per week in school lunch participation contributed to a significant KIDMED score increase of 0.091 (Table 7). However, there was no significant association between school lunch participation and BMI and WHtR (Tables 6 and 7).

Furthermore, we found a significant correlation between FAS score and BMI (r^P= -0.073; p<0.039), WHtR (r^P= - 0.097; p<0.006), and KIDMED (r^P= 0.174; p<0.001), maintained after adjustment. Students with higher socioeconomic status had a greater adherence to the MDP and healthier BMI and WHtR (Table 7).

Female students had a significantly lower WHtR of -0.014, compared to males. Non-Portuguese students had a significant decrease in KIDMED scores of -0.07. Students in lower grades had a significantly healthier WHtR and BMI (Table 7).

The variables age, grade, and FRPM were not significant and were withdrawn from the model.

Table 7. Associations between BMI, WHtR, and KIDMED and average weekly school lunch participation, adjusted for gender, nationality, and FAS.

	WHtR (R^2 adjusted = 0.021)				**Z-BMI** (R^2 adjusted = 0.001)				**KIDMED** (R^2 adjusted = 0.039)			
	Unadjusted analysis		Adjusted analysis		Unadjusted analysis		Adjusted analysis		Unadjusted analysis		Adjusted analysis	
	Value	*p*	β_{adj}	*p*	Value	*p*	β_{adj}	*p*	Value	*p*	β_{adj}	*p*
Average weekly school lunch participation, correlation	0.019	0.595	-0.001	0.553	0.004	0.905	-0.003	0.915	0.083	**0.018**^{S*}	0.091	**0.031***
Gender, mean (SD)												
Female	0.43 (0.05)	**<0.001**^{T*}	-0.014	**<0.001***	0.56 (1.27)	0.599	-0.054	0.568	6.16 (2.46)	0.885	0.056	0.731
Male	0.44 (0.06)		0		0.61 (1.38)		0		6.14 (2.30)		0	
Nationality, mean (SD)												
Non-Portuguese	0.43 (0.05)	0.701	-0.006	0.358	0.75 (1.24)	0.210	0.135	0.377	5.31 (2.09)	**<0.001***	-0.070	**0.009***
Portuguese	0.43 (0.06)		0		0.57 (1.34)		0		6.26 (2.39)		0	
FAS, correlation	-0.097	**0.006**^{P*}	-0.003	**0.003***	-0.073	**0.039**^{P*}	-0.037	0.110	0.174	**<0.001**^{P*}	0.179	**<0.001***
Age, correlation	-0.043	0.226			-0.036	0.307			-0.045	0.206		
Grade, correlation	-0.105	**0.003**^{S*}			-0.075	**0.034**^{S*}			-0.003	0.941		
Students eligible for FRPM, correlation	-0.022	0.537			0.010	0.774			0.054	0.125		

WHtR – Waist-to-Height ratio; Z-BMI – Z-score Body Mass Index; KIDMED - Mediterranean Diet Quality Index; FAS – Family Affluence Scale; FRPM – Free or Reduced Price Meals; β – adjusted effect; P - Pearson correlation; S - Spearman correlation; T – *t*-test; Age, Grade, and FRPM variables were not included in the model.

4. Discussion

4.1. Main Findings

Students' school lunch participation was significantly associated with age, school grade, eligibility to FRPM, and adherence to MDP. Younger students, mainly from 2nd cycle, eligible for free or reduced-price meals participated at a higher rate. Students that had a higher participation rate had a better diet.

The average student's daily participation rate was 25.3%, with a higher rate for 2nd cycle students (26.6%) than for 3rd cycle students (19.3%). These results are much lower than the 42% reported by Madeira in 2014 [19] and showed very low adherence to school lunches by Benavente students. Adults' participation rate was astonishingly low (2%), revealing that almost all professors and school staff chose not to have lunch in the canteen. This result was also found in the Thompson *et al.* study [35]. According to Martins *et al.* [36], the acceptability of a food unit can be classified into four categories: high (adherence above 70%), medium (50 to 70%), low (30 to 50%), and very low (below 30%). According to this classification, the degree of Benavente school food service acceptance was very low, since only 25% of students and 2% of adults attended the school canteen every day.

Students' main reasons for school lunch participation were the schedule, having no one at home, and lunch quality. On the other hand, students that never ate in the school canteen refer that the primary reasons are that they lived close by and disliked the food served. These results align with a recent study on Portuguese adolescents' health that reported that 54.4% of students consider lunches their least favorite thing at school [37]. Disliking the taste of school lunches is one of the most frequently mentioned reasons for non-participation [17,38,39].

4.2. Association between school lunch participation and adherence to the MDP, BMI, and WHtR

One of the most relevant results of this study was the positive association between adherence to MDP and school lunch participation. Our results reinforce the assumption that school meals have the potential to improve children's diets and add to the body of evidence [8-11]. A French cross-sectional study also found an association between school lunch participation and healthier eating habits among adolescents [39].

However, key learning from this study is the need to improve MDP adherence among Benavente students, as the majority (71.2%) had low/moderate adherence and only 28.8% had high adherence to MDP. The present results showed a pronounced abandonment of traditional MDP which is seen in reduced consumption of fruits, vegetables, pulses, and nuts. These results were quite lower than other studies performed in Portugal. For example, 45.5% of students in the Algarve region, had a high adherence, and 54.5% had a low/moderate adherence to MDP [40]. Furthermore, De Moraes *et al.*, found that half of Portuguese adolescents have an unhealthy dietary pattern, characterized by a lower consumption of fruits, vegetables, and pulses and a higher consumption of sugar-sweetened beverages [3]. Several studies indicate that adherence to MDP among adolescents has been decreasing in Mediterranean countries [41].

In Benavente Municipality, the prevalence of overweight was 23.6% and obesity was 16.1%. Our data showed a higher prevalence of obesity than the data last reported in the Portuguese National Food and Physical Activity Survey (8.7%) [1]. Additionally, 13.8% of Benavente students had an increased risk of cardiovascular disease.

One advantage of school meals pointed out by several authors is the potential to fight the childhood obesity epidemic [12]. However, this study found no evidence of an association between school lunch participation and BMI and WHtR. This result is consistent with previous works [13,42-44] and can be explained by the influence of food eaten outside the school canteen and physical activity level.

In this study, we found an association between BMI, WHtR, and MDP. Students with higher BMI had higher WHtR and low adherence to MDP. Significant negative associations between MDP adherence and BMI have been reported in several studies [45-47]. On the other hand, Voltas and colleagues [48], reported no association between anthropometry measurements and adherence to MDP in Spanish adolescents. In Portugal, some studies also found no associations [49].

4.3. Association between school lunch participation and socioeconomic status

We could observe an association between FRPM and school lunch participation. Students who are not eligible for FRPM went less often to the school canteen. This finding is in line with American reports [17].

Furthermore, there was an association between FAS and MDP, BMI and WHtR. Students from low-affluence families had lower adherence to MDP and higher BMI and WHtR. Several studies from Portugal [50], Italy [45], Greece [51], and Spain [32] have reported similar results. Low-income students tend to have less access to healthy food [52], poorer dietary quality [53] as well as a higher risk of obesity [2,54,55]. Interestingly, a recent study with a representative sample of the Portuguese population found that dietary costs increase with greater adherence to MDP [56] explaining why low adherence to MDP is associated with poor socioeconomic status [57].

These findings are important considering that the Portuguese school lunch program is committed to the principles sustaining MDP [16] has a reduced controlled cost of 1.46 € and is eligible for FRPM application, constituting a great opportunity, especially for students from low-income families, to improve their diet quality. However, in our study, only 27% (n = 72) of the students eligible for FRPM had an effective adherence to school lunch and surprisingly 31% (n = 83) of the students with economic support chose never to eat lunch at the school canteen. This may be due to a stigmatizing problem already described by other authors [7,20]. In Portugal, an individualized electronic student card

is used to book and pay for meals. However, the student's eligibility for FRPM information is available to all students when the card is used in the canteen service line. Keeping this information hidden from other students could be a possible way to fight stigmatization around FRPM.

4.4. Study implications

Ensuring the effective implementation of current Portuguese school food guidelines by defining a model for supervising compliance is an essential political priority action set by the recent Portuguese National Program for the Promotion of Healthy Eating [58,59]. Of no lesser importance should be the investment in actions to promote school lunch participation and satisfaction. Otherwise, we risk having perfectly safe and nutritious school meals served to just a minor percentage of students, mostly from low-income families that do not have any other option.

Several strategies that can increase school lunch participation have been studied in a recent systematic review [60]. These include taste tests [61], modified menu options [62], changes to the canteen environment [63], policy restrictions on competitive foods [64], and implementation of nutrition standards [65]. Universal free school lunches (UFSL), free meals to all students regardless of family household income, is also considered a possible action to increase participation [6]. In this case, two key mechanisms can work together to improve school lunch participation. First, students who are not eligible for FRPM get free lunch, increasing the participation of non-poor students. Second, UFSL may reduce the stigma of participating in school lunch which can, in principle, affect all students [13].

To achieve higher school lunch participation, students' opinions as consumers must be collected to understand their requirements. Also, more ambitious policies and public investment are necessary for high food service quality. A higher budget for food provision is essential, hiring more staff, acquiring modern equipment, and redesigning the lunchroom, making it an appealing experience and hopefully stopping the widespread associations of school lunches with bland food and second-class meals [14].

4.5. Strengths and Weaknesses

One limitation of this study was its scope. Our study examined a large sample size of 2nd and 3rd cycle students from Benavente but represented only a small study population from Portugal. Thus, a further study with a representative sample from all Portuguese regions would be an interesting next step.

Also, the study's cross-sectional design does not allow the analysis of cause and effect.

On the other hand, to our best knowledge, this was the first study in Portugal to study associations between school lunch participation and MDP, BMI, and WHtR.

5. Conclusions

Our findings suggested that a greater school lunch participation rate was positively and significantly associated with higher adherence to MDP. On the other hand, greater adherence to MDP was associated with healthier BMI and WHtR. These results reinforce the role of school lunches in promoting a sustainable healthy diet in students and stress the need for more investment in the school food service. The next step should be co-creating a school food service able to serve not only safe and nutritious meals but also one that students and parents consider an enjoyable place to have lunch. Ignoring that the school canteen is more than a place to eat a healthy lunch will undermine the success of all the policy interventions.

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References

1. Lopes, C.; Torres, D.; Oliveira, A.; Severo, M.; Alarcão, V.; Guiomar, S.; Mota, J.; Teixeira, P.; Rodrigues, S.; Lobato, L. Inquérito Alimentar Nacional e de Atividade Física IAN-AF 2015-2016: relatório de resultados. **2017**.
2. OECD. Health at a Glance 2021: OECD Indicators. Available online: https://doi.org/10.1787/ae3016b9-en
3. de Moraes, M.M.; Oliveira, B.; Afonso, C.; Santos, C.; Torres, D.; Lopes, C.; Miranda, R.C.; Rauber, F.; Antoniazzi, L.; Levy, R.B.; et al. Dietary Patterns in Portuguese Children and Adolescent Population: The UPPER Project. *Nutrients* **2021**, *13*, doi:10.3390/nu13113851.
4. Direção-Geral da Saúde. Programa Nacional para a Promoção da Alimentação Saudável 2022-2030. **2022**.
5. Institute for Health Metrics and Evaluation (IHME). Global Burden Disease Portugal 2019. Available online: https://www.healthdata.org/research-analysis/health-by-location/profiles/portugal
6. Cohen, J.F.W.; Hecht, A.A.; McLoughlin, G.M.; Turner, L.; Schwartz, M.B. Universal School Meals and Associations with Student Participation, Attendance, Academic Performance, Diet Quality, Food Security, and Body Mass Index: A Systematic Review. *Nutrients* **2021**, *13*, 911.
7. Bailey-Davis, L.; Virus, A.; McCoy, T.A.; Wojtanowski, A.; Vander Veur, S.S.; Foster, G.D. Middle School Student and Parent Perceptions of Government-Sponsored Free School Breakfast and Consumption: A Qualitative Inquiry in an Urban Setting. *Journal of the Academy of Nutrition and Dietetics* **2013**, *113*, 251-257.
8. Condon, E.M.; Crepinsek, M.K.; Fox, M.K. School meals: types of foods offered to and consumed by children at lunch and breakfast. *Journal of the American Dietetic Association* **2009**, *109*, S67-S78.
9. Taber, D.R.; Chriqui, J.F.; Powell, L.; Chaloupka, F.J. Association between state laws governing school meal nutrition content and student weight status: implications for new USDA school meal standards. *JAMA Pediatr* **2013**, *167*, 513-519.
10. Au, L.E.; Rosen, N.J.; Fenton, K.; Hecht, K.; Ritchie, L.D. Eating School Lunch Is Associated with Higher Diet Quality among Elementary School Students. *J Acad Nutr Diet* **2016**, *116*, 1817-1824.
11. Evans, C.E.L.; Harper, C.E. A history and review of school meal standards in the UK. *Journal of Human Nutrition and Dietetics* **2009**, *22*, 89-99.
12. Kenney, E.L.; Barrett, J.L.; Bleich, S.N.; Ward, Z.J.; Cradock, A.L.; Gortmaker, S.L. Impact Of The Healthy, Hunger-Free Kids Act On Obesity Trends: Study examines impact of the Healthy, Hunger-Free Kids Act of 2010 on childhood obesity trends. *Health Affairs* **2020**, *39*, 1122-1129.
13. Schwartz, A.E.; Rothbart, M.W. Let Them Eat Lunch: The Impact of Universal Free Meals on Student Performance. *Journal of Policy Analysis and Management* **2020**, *39*, 376-410.

14. Truninger, M.; Teixeira, J.; Horta, A.; da Silva, V.A.; Alexandre, S. Schools' health education in Portugal: A case study on children's relations with school meals. *Educação, Sociedade & Culturas* **2013**, 117-133.
15. O'Connell, R.; Brannen, J.; Ramos, V.; Skuland, S.; Truninger, M. School meals as a resource for low-income families in three European countries: a comparative case approach. *European Societies* **2022**, *24*, 251-282.
16. Direção-Geral da Educação. Circular nº.: 3097/DGE/2018. *Orientações sobre ementas e refeitórios escolares* **2018-08-08**.
17. Fox, M.K.; Gearan, E.; Cabili, C.; Dotter, D.; Niland, K.; Washburn, L.; Paxton, N.; Olsho, L.; LeClair, L.; Tran, V. *School Nutrition and Meal Cost Study final report volume 4: Student participation, satisfaction, plate waste, and dietary intakes*; Mathematica Policy Research: 2019.
18. Sobek, C.; Ober, P.; Abel, S.; Spielau, U.; Kiess, W.; Meigen, C.; Poulain, T.; Igel, U.; Vogel, M.; Lipek, T. Purchasing behavior, setting, pricing, family: Determinants of school lunch participation. *Nutrients* **2021**, *13*, 4209.
19. Madeira, B.M.C. Adesão aos refeitórios escolares no 2º, 3º ciclos e ensino secundário. Instituto Superior de Ciências da Saúde Egas Moniz, 2014.
20. Mirtcheva, D.M.; Powell, L.M. Participation in the National School Lunch Program: Importance of School-Level and Neighborhood Contextual Factors. *Journal of School Health* **2009**, *79*, 485-494.
21. Marples, C.A.; Spillman, D.M. Factors affecting students' participation in the Cincinnati public schools lunch program. *Adolescence* **1995**, *30*, 745-754.
22. Murimi, M.; Chrisman, M.; McCollum, H.; Mcdonald, O. A qualitative study on factors that influence students' food choices. *Journal of Nutrition and Health* **2016**, *2*, 1-6.
23. Virtanen, M.; Kivimäki, H.; Ervasti, J.; Oksanen, T.; Pentti, J.; Kouvonen, A.; Halonen, J.I.; Kivimäki, M.; Vahtera, J. Fast-food outlets and grocery stores near school and adolescents' eating habits and overweight in Finland. *The European Journal of Public Health* **2015**, *25*, 650-655.
24. Ministério da Educação e Ciência - Gabinete do Secretário de Estado do Ensino e da Administração Escolar. Despacho n.º 8452-A/2015. *Diário da República Série-II*, 22 - 27.
25. Inchley, J.; Currie, D.; Cosma, A.; Samdal, O. Health behaviour in school-aged children (HBSC) study protocol: background, methodology and mandatory items for the 2017/18 survey. St Andrews: CAHRU. **2018**.
26. Hartley, J.E.K.; Levin, K.; Currie, C. A new version of the HBSC Family Affluence Scale - FAS III: Scottish Qualitative Findings from the International FAS Development Study. *Child Indic Res* **2016**, *9*, 233-245.
27. Stewart, A.; Marfell-Jones, M.; Olds, T.; De Ridder, J. *International Standards for Anthropometric Assessment*; International Society for the Advancement of Kinanthropometry: 2011; Volume 137.
28. World Health Organization. WHO AnthroPlus for personal computers manual: software for assessing growth of the world's children and adolescents. *Geneva: WHO* **2009**.
29. Onis, M.d.; Onyango, A.W.; Borghi, E.; Siyam, A.; Nishida, C.; Siekmann, J. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World health Organization* **2007**, *85*, 660-667.
30. Ashwell, M.; Gibson, S. Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix' based on BMI and waist circumference. *BMJ Open* **2016**, *6*, e010159.
31. Browning, L.M.; Hsieh, S.D.; Ashwell, M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. *Nutr Res Rev* **2010**, *23*, 247-269.
32. Serra-Majem, L.; Ribas, L.; Ngo, J.; Ortega, R.M.; García, A.; Pérez-Rodrigo, C.; Aranceta, J. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutr* **2004**.

33. Rei, M.; Severo, M.; Rodrigues, S. Reproducibility and validity of the Mediterranean Diet Quality Index (KIDMED Index) in a sample of Portuguese adolescents. *Br. J. Nutr.* **2021**, *126*, 1737-1748.
34. Sturion, G.L.; Silva, M.V.d.; Ometto, A.M.H.; Furtuoso, M.C.O.; Pipitone, M.A.P. Fatores condicionantes da adesão dos alunos ao Programa de Alimentação Escolar no Brasil. *Revista de Nutrição* **2005**, *18*, 167-181.
35. Thompson, H.R.; Gosliner, W.; Ritchie, L.; Wobbekind, K.; Reed, A.L.; O'Keefe, O.; Madsen, K.A. The Impact of a Multipronged Intervention to Increase School Lunch Participation among Secondary School Students in an Urban Public School District. *Child Obes* **2020**, *16*, S14-s22.
36. Bertolo, M.; Medeiros, M.A.; Ragonha, G.; Olbi, J.; Segatti, M.; Osele, M. Aceitabilidade da Alimentação Escolar no Ensino Público Fundamental. *Saúde em Revista* **2004**, *6*, 71-78.
37. Matos, M.; Guedes, F.; Social, E.A. *A saúde dos adolescentes portugueses em contexto de pandemia - Dados nacionais do estudo HBSC 2022*; 2022.
38. Fox, M.K.; Gearan, E. *School Nutrition and Meal Cost Study: Summary of Findings*; Mathematica Policy Research: 2019.
39. Dubuisson, C.; Lioret, S.; Dufour, A.; Volatier, J.L.; Lafay, L.; Turck, D. Associations between usual school lunch attendance and eating habits and sedentary behaviour in French children and adolescents. *European Journal of Clinical Nutrition* **2012**, *66*, 1335-1341.
40. Bôto, J.M.; Marreiros, A.; Diogo, P.; Pinto, E.; Mateus, M.P. Health behaviours as predictors of the Mediterranean diet adherence: a decision tree approach. *Public Health Nutrition* **2022**, *25*, 1864-1876.
41. Iaccarino Idelson, P.; Scalfi, L.; Valerio, G. Adherence to the Mediterranean Diet in children and adolescents: A systematic review. *Nutrition, Metabolism and Cardiovascular Diseases* **2017**, *27*, 283-299.
42. Gleason, P.M.; Dodd, A.H. School Breakfast Program but Not School Lunch Program Participation Is Associated with Lower Body Mass Index. *Journal of the American Dietetic Association* **2009**, *109*, S118-S128.
43. Bardin, S.; Gola, A.A. Analyzing the Association between Student Weight Status and School Meal Participation: Evidence from the School Nutrition and Meal Cost Study. *Nutrients* **2021**, *13*, 17.
44. Baxter, S.D.; Hardin, J.W.; Guinn, C.H.; Royer, J.A.; Mackelprang, A.J.; Devlin, C.M. Children's body mass index, participation in school meals, and observed energy intake at school meals. *International Journal of Behavioral Nutrition and Physical Activity* **2010**, *7*, 24.
45. Grosso, G.; Marventano, S.; Buscemi, S.; Scuderi, A.; Matalone, M.; Platania, A.; Giorgianni, G.; Rametta, S.; Nolfo, F.; Galvano, F.; et al. Factors Associated with Adherence to the Mediterranean Diet among Adolescents Living in Sicily, Southern Italy. *Nutrients* **2013**, *5*, 4908-4923.
46. Kontogianni, M.D.; Farmaki, A.-E.; Vidra, N.; Sofrona, S.; Magkanari, F.; Yannakoulia, M. Associations between Lifestyle Patterns and Body Mass Index in a Sample of Greek Children and Adolescents. *Journal of the American Dietetic Association* **2010**, *110*, 215-221.
47. Schröder, H.; Mendez, M.A.; RIBAS‐BARBA, L.; COVAS, M.I.; SERRA‐MAJEM, L. Mediterranean diet and waist circumference in a representative national sample of young Spaniards. *International Journal of Pediatric Obesity* **2010**, *5*, 516-519.
48. Voltas, N.; Arija, V.; Aparicio, E.; Canals, J. Longitudinal study of psychopathological, anthropometric and sociodemographic factors related to the level of Mediterranean diet adherence in a community sample of Spanish adolescents. *Public Health Nutrition* **2016**, *19*, 1812-1822.
49. Pinto, E.; Bôto, J.M.; Mateus, M.P. Hábitos alimentares, de saúde e adesão à Dieta Mediterrânica dos jovens da região do Algarve. **2020**.

50. Santos, R.; Moreira, C.; Abreu, S.; Lopes, L.; Ruiz, J.R.; Moreira, P.; Silva, P.; Mota, J. Parental Education Level Is Associated With Clustering of Metabolic Risk Factors in Adolescents Independently of Cardiorespiratory Fitness, Adherence to the Mediterranean Diet, or Pubertal Stage. *Pediatric Cardiology* **2014**, *35*, 959-964.
51. Costarelli, V.; Sdrali, D.; Konstantopoulou, A. Mediterranean diet and socio-economic status in Greek adolescents. *Nutrition and Food Science* **2013**, *43*, 535-542.
52. Larson, N.; Story, M. Barriers to Equity in Nutritional Health for U.S. Children and Adolescents: A Review of the Literature. *Current Nutrition Reports* **2015**, *4*, 102-110.
53. Thomson, J.L.; Tussing-Humphreys, L.M.; Goodman, M.H.; Landry, A.S. Diet quality in a nationally representative sample of American children by sociodemographic characteristics. *The American Journal of Clinical Nutrition* **2019**, *109*, 127-138.
54. Veugelers, P.J.; Fitzgerald, A.L. Prevalence of and risk factors for childhood overweight and obesity. *Cmaj* **2005**, *173*, 607-613.
55. Mohd Saat, N.Z.; Abd Talib, R.; Alarsan, S.F.; Saadeh, N.; Shahrour, G. Risk Factors of Overweight and Obesity Among School Children Aged 6 to 18 Years: A Scoping Review. *Nutrition and Dietary Supplements* **2023**, *15*, 63-76.
56. Alves, R.M.; Lopes, C.M.M.; Rodrigues, S.S.P.; Perelman, J. Adhering to a Mediterranean diet in a Mediterranean country: an excess cost for families? *Br. J. Nutr.* **2022**, *128*, 1393-1400.
57. Mendonça, N.; Gregório, M.J.; Salvador, C.; Henriques, A.R.; Canhão, H.; Rodrigues, A.M. Low Adherence to the Mediterranean Diet Is Associated with Poor Socioeconomic Status and Younger Age: A Cross-Sectional Analysis of the EpiDoC Cohort. *Nutrients* **2022**, *14*, 1239.
58. Gregório, M.; Salvador, C.; Bica, M.; Graça, P.; Telo de Arriaga, M. The Healthy Food Environment Policy Index (Food-EPI): Relatório de resultados para Portugal. *Lisboa: Programa Nacional para a Promoção da Alimentação Saudável, Direção Geral da Saúde* **2022**.
59. Pineda, E.; Poelman, M.P.; Aaspõllu, A.; Bica, M.; Bouzas, C.; Carrano, E.; De Miguel-Etayo, P.; Djojosoeparto, S.; Blenkuš, M.G.; Graca, P. Policy implementation and priorities to create healthy food environments using the Healthy Food Environment Policy Index (Food-EPI): A pooled level analysis across eleven European countries. *The Lancet Regional Health–Europe* **2022**, *23*.
60. Hecht, A.A.; Olarte, D.A.; McLoughlin, G.M.; Cohen, J.F.W. Strategies to Increase Student Participation in School Meals in the United States: A Systematic Review. *J Acad Nutr Diet* **2023**.
61. Pope, L.; Roche, E.; Morgan, C.B.; Kolodinsky, J. Sampling tomorrow's lunch today: Examining the effect of sampling a vegetable-focused entrée on school lunch participation, a pilot study. *Preventive Medicine Reports* **2018**, *12*, 152-157.
62. Rafferty, K.; Zipay, D.; Patey, C.; Meyer, J. Milk enhancements improve milk consumption and increase meal participation in the NSLP: the School Milk Pilot Test. *Journal of Child Nutrition and Management* **2009**, *33*.
63. Koch, P.A.; Wolf, R.L.; Trent, R.; Guerra, L.A. School Transformation after Redesign of 3 Cafeterias (STARCafé). *Health Behavior and Policy Review* **2020**, *7*, 329-341.
64. Boehm, R.; Read, M.; Henderson, K.E.; Schwartz, M.B. Removing competitive foods v. nudging and marketing school meals: a pilot study in high-school cafeterias. *Public Health Nutrition* **2020**, *23*, 366-373.
65. Cohen, J.F.W.; Gorski, M.T.; Hoffman, J.A.; Rosenfeld, L.; Chaffee, R.; Smith, L.; Catalano, P.J.; Rimm, E.B. Healthier Standards for School Meals and Snacks: Impact on School Food Revenues and Lunch Participation Rates. *American Journal of Preventive Medicine* **2016**, *51*, 485-492.

3.3 ARTIGO 3

Impact of a co-created intervention on school lunch participation and satisfaction in 2nd and 3rd cycles students of basic education in Portugal, Benavente: R23 quasi-experimental study

Article

Impact of a co-created intervention on school lunch participation and satisfaction in 2nd and 3rd cycles students of basic education in Portugal, Benavente: R23 quasi-experimental study

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Abstract: School lunch offers an opportunity to tackle the current problems of over- and unsustainable consumption by promoting sustainable healthy diets in children and shaping healthy future generations of consumers. This study aimed to evaluate the impact of a co-created intervention on school lunch participation and satisfaction (plate waste), adherence to the Mediterranean Dietary Pattern (MDP), Body Mass Index (BMI), and Waist-to-Height Ratio (WHtR). In the school year 2022-23, a quasi-experimental study was conducted in two 2nd and 3rd cycle schools from Benavente, Portugal. One school received the co-created intervention: redesign of the lunchroom, meal service, and menu. Implementing the co-creator's proposals led to a significant increase in students' school lunch participation, from 22.1% to 27.4%, representing a 24.0% increase. Also, the intervention significantly reduced WHtR but not BMI, MDP, and satisfaction. This innovative study provided evidence of the effectiveness of co-created interventions in increasing school lunch participation and further impacting the reduction of the prevalence of students with increased risk of cardiovascular disease.

Keywords: school lunch participation; co-creation; students; school meal service; school menu; lunchroom environment; Mediterranean Dietary Pattern; body mass index; waist-to-height ratio;

1. Introduction

The relationship between food, environment, and health is currently on the world agenda [1]. Production, processing, distribution, consumption, and food waste are important drivers of several environmental pressures, particularly regarding climate change, water use, greenhouse gas emissions (GHG), nitrogen and phosphorous cycle imbalances, and loss of biodiversity [2-5]. On the other hand, since 2000, the prevalence of overweight and obesity has increased globally in all age groups, including children and adolescents [6]. In Portugal, the scenario is similar [7]. If no concrete actions are taken, these numbers

are expected to rise during the next decade [8]. Moreover, according to projections from the Institute for Health Metrics and Evaluation (IHME), 13.8% of projected deaths in 2030 will be attributable to dietary risk factors in Portugal. Overweight and obesity will be attributed to 12.0%, exceeding smoking, whose projected percentage of attributable deaths will be 11.1% [9]. Adding to health and environmental impacts we cannot ignore the burden of food insecurity. One in six Portuguese citizens [10] and 9.5% of Portuguese children are food insecure [11].

School lunch programs can be part of the strategy to respond to these global problems since they are considered an important tool for promoting sustainable healthy diets in children and shaping healthy future generations of consumers [12,13] and have been described as having higher nutritional quality compared with meals from home [14-17]. Children who have more lunches in school consume more vegetables, fruits, cereals, and fish and present better dietary adequacy [22].

A huge effort has been taking place in Portugal to improve the school food environment. All the legislation published in the last decade significantly improved the quality of lunches served in Portuguese schools [18-25]. However, school lunch participation rates remain low, especially among middle and high school students [26]. Although 33% of students in Benavente schools were eligible for Free Reduced Price Meals (FRPM), overall participation was remarkably low (25.3%, Artigo 2). According to this study, 39% of students never went to the canteen, and 31% of students eligible for FRPM chose to never eat lunch at the school canteen despite the economic support. School lunch participation barriers mentioned in the literature are varied and include long canteen waiting lines [27], unpleasant lunchroom environment [28], dislike of the taste of the school lunch [29], noise during lunchtime, canteen capacity, unappealing meals [30] and stigma associated with being low-income student relying on the school meal program [31-33].

There is a clear need to bridge the gap between healthy nutritional school guidelines and the practical implementation of a school food service that attracts students. Although students are the main group interested in these changes, they have yet to be included in policy definitions. Traditionally, top-bottom approaches are used in school canteen intervention projects, with modest results [34]. Considering that, for the school lunch programs to accomplish their goals achieving high school participation levels is crucial. For that to happen, it is necessary to align with what students consider valuable [35]. Therefore, an innovative intervention approach like participatory design, also known as co-creation, a bottom-up approach, is necessary, [36]. Co-creation refers to the collaborative development of public health interventions considering stakeholders' input (co-creators), scientific evidence, and participatory principles [36-38]. The potential of co-creation has been demonstrated in several studies [38-41].

This study aimed to evaluate the impact of a co-created intervention on school lunch participation and satisfaction, adherence to the Mediterranean Dietary Pattern (MDP), Body Mass Index (BMI), and Waist-to-Height Ratio (WHtR). We hypothesized that redesigning the menu, lunchroom, and meal service with the school community would increase school lunch participation and satisfaction, decreasing plate waste. As a result, we expected an increase in adherence to MDP and a decrease in BMI and WHtR.

2. Materials and Methods

2.1. Study population and design

This was one school year quasi-experimental study in Portugal, Benavente, with a multi-component intervention and a co-creation participatory methodology, two schools, one intervention and one control school, 2nd and 3rd cycle of basic education. This study follows the Guidelines for non-randomized/quasi-experimental study designs (TREND) [42] and uses the co-creation framework proposed by Leask et al [36]. The detailed protocol of the R23 quasi-experimental study has been published elsewhere (Artigo 1).

The study was approved by the Faculty of Food and Nutrition Science of the University of Porto Ethics Committee (118/2023/CEFCNAUP). All participants were informed of the study's goals and written informed consent was obtained from parents or tutors.

2.2. Co-creation of the intervention

The R23 project had a participatory design, also known as co-creation, a bottom-up approach.

Redesigning the school meal service, menu, and lunchroom environment were the main components of the intervention developed during the co-creation process. These three components are considered the most important in school meals customer satisfaction [35].

2.2.1. Co-creation team

The co-creation project team comprised two nutritionists assisted by three other experts in nutrition science, innovation, and statistics.

2.2.2. Sampling and recruitment

A convenient sample of the school community was made, and elected school community representatives were invited to participate in the project: student class delegates, parents' representatives of each class, school council, students' association, parents' association, and municipal counselor. These co-creators were expected to be more motivated to participate in this project as they already played an active role in the school community. All co-creators had equal sharing of power.

2.2.3. Workshops "DL, mudámos a cantina!"

Two workshops were conducted in the intervention school lunchroom. The co-creation team facilitated the workshops while the school director and school coordinator acted as co-facilitators and observed the workshops. Each workshop was 120 minutes in duration. Participants were assigned randomly to groups of six.

The co-creation process started with the statement of the problem "Low school lunch participation" and the proposal of the following objective: "Design an intervention that revolutionizes the menu, meal service and lunchroom environment, creating a food service that is attractive to students and parents".

In the workshops, several interactive techniques from design thinking were used, like: "How might we...?", Brainstorming, and Affinity mapping. The following question was put to the co-creators: "*How might we redesign the food service to increase school lunch participation and satisfaction?"*. For 20 minutes, each group wrote all the ideas for each intervention component in Post-its and put them on the group cardboard. Next, all the groups presented their ideas, and a discussion was promoted. The outcome was a set of proposals summarized on a big paperboard that all co-creators agreed to be important to implement to increase school lunch participation and satisfaction. This cardboard was posted on the lunchroom wall for all the students to see during lunchtime in the following weeks. Afterward, a tea break was offered to all co-creators.

An online communication platform was created so that the discussion could continue, and the evolution of the project could be shared with all co-creators.

2.3. Measurements

All measurements were done at baseline and follow-up, in both control and intervention schools, except for the variable "school lunch participation rate", which was calculated for all school days. Three previously trained researchers conducted a face-to-face interviewer-administered questionnaire designed by the authors. The questionnaire had

four parts: sociodemographic, socioeconomic status, adherence to the Mediterranean Dietary Pattern, and school lunch participation.

School lunch participation rates and satisfaction were the primary outcomes. Satisfaction was assessed through plate waste quantification. Secondary outcomes included BMI, WHtR, and adherence to MDP.

2.3.1. Sociodemographic and socioeconomic status

Date of birth, nationality, grade, and gender were collected for each student.

Socioeconomic status was evaluated using two indicators: information from eligibility to subsidize free or reduced-price meals (FRPM), obtained via the school administrative database, and with a scale that indirectly determines family wealth.

Portugal has a three-tier system for paying for school lunches (A, B and C). Students in the lowest income group are entitled to a free school lunch (A), those in the following category pay half the cost (B), while the rest pay the full amount currently set at €1.46. (C).

The Family Affluence Scale (FAS) used in the protocol of the international study Health Behaviour in School-aged Children (HBSC) [43] is a way of assessing family wealth. The FAS includes items that reflect the family's material resources, its consumption patterns, and its purchasing power [44]. The FAS score was calculated for each student based on the answers to 6 questions, on a scale ranging from 0 to 13 points, where higher values indicate a higher economic level.

2.3.2. School lunch participation

Adherence to the school canteen was studied in two ways, through the daily number of lunches served in each school canteen and through the answers obtained in the questionnaire applied to students.

The number of meals served per day was obtained through the EduBOX SIGA platform (Integrated Management and Learning System), which manages the school meal booking service. The average participation rates (PR) were calculated according to the following formulas:

$$PR_{Adults}\ (\%) = \text{No. of meals served to adults} / \text{No. Adults working in school} \times 100 \quad (1)$$

$$PR_{Students}\ (\%) = \text{No. of meals served to students} / \text{No. of enrolled students} \times 100 \quad (2)$$

$$PR_{FRPM}\ (\%) = \text{No. of meals served to FRPM students} / \text{No. of enrolled FRPM students} \times 100 \quad (3)$$

The number of enrolled students was updated every week as students enrolled and left throughout the school year. Also, the number of students eligible for FPRM was updated weekly because this status can change throughout the school year.

With the question "On average, how many days a week do you have lunch in the canteen?" another variable was obtained, whose responses were categorized according to Sturion *et al.* [45] as: non-adherence (nonparticipation), partial adherence (participation one to three times a week) and effective adherence (participation four to five times a week).

2.3.3. School Lunch Satisfaction

A way to assess lunch satisfaction is plate waste (PW) quantification [33,46]. Plate waste quantification was done in eight nonconsecutive days. Plate waste corresponds to edible food served that is not eaten. An aggregate weighing method was used, which consists of weighing together all the food items left on the plate of each student [47,48]. Plate waste was separated into different containers, whose weight was discounted, according to the type of food: soup, main course, and side dish (vegetables).

Plate waste index (1) was obtained by the ratio between plate waste and the quantity of food served [46].

$$PW\ (\%) = PW/\text{quantity of food served} \times 100, \quad (1)$$

To quantify the food served, the prepared food was weighed in the respective containers before distribution began and when it ended, discounting the weight of the containers.

2.3.4. Anthropometry

Anthropometric measurements were performed according to recommendations [49], in the physical education classes. Weight, height, and waist circumference (WC) were measured using a portable electronic weight scale (Seca 877, Hamburg, Germany), a portable stadiometer (Seca 217), and a measurement tape (Seca 203), respectively, with the participant barefoot wearing light clothing.

Body mass index (BMI)-for-age *Z*-scores were calculated using the World Health Organization (WHO) software Anthroplus [50]. The WHO cut-off points were used [51].

Waist-to-Height ratio (WHtR) was calculated by dividing WC by height and categorized as follows: < 0.5 appropriate, and ≥ 0.5 increased risk of cardiovascular disease [52,53].

2.3.5. Adherence to Mediterranean Dietary Pattern

To assess adherence to the Mediterranean Dietary Pattern (MDP) the KIDMED (Mediterranean Diet Quality Index for Children and Adolescents) questionnaire was applied [54]. The KIDMED score was calculated from sixteen yes/no questions, validated for Portuguese adolescents [55]. The final scores of the KIDMED index vary between -4 and 12 points, with higher scores indicating higher adherence to the Mediterranean diet. Students were classified into three categories: ≥ 8, high adherence (optimal Mediterranean diet; 4-7, moderate adherence (improvement is needed to adjust intake to Mediterranean patterns), and ≤ 3, low adherence (very low diet quality).

2.4. Statistical analysis

Descriptive data were presented as mean and standard deviation (SD) for continuous variables, or the frequency (number and percentage) for categorical variables. Normality was tested in cardinal variables in samples higher than 50 using the asymmetry and flatness coefficients criteria, considering that the variable has a normal distribution when these coefficients are between [-2 and 2] [56]. When the sample is less than 50, normality was tested using the Shapiro-Wilk test.

Paired samples *t*-test or Mann-Whitney *U*-test was used to compare within schools at baseline and follow-up.

In intervention and control schools, a delta (Δ) was calculated to assess the percentage point of change between baseline and follow-up.

To assess the impact of the intervention in the main variable school lunch participation rate (PR) Pearson correlation with time was used.

Two-way ANCOVA (General Linear Model, univariate), was used to evaluate the impact of the intervention on plate waste.

ANCOVA for repeated measures (General Linear Model), was used to evaluate the impact of the intervention, between baseline and follow-up, in intervention and control schools, in the variables BMI, WHtR, and KIDMED. Fixed factors (gender, nationality, grade, and FRPM) and covariates (age, FAS) were entered into the ANCOVA models. The final model was determined using stepwise backward deletion until the adjusted R^2 decreased. The effect size was interpreted using the value of the partial eta squared (η_p^2) through a qualitative definition of between-subject effects [57]. This criterion identifies the

overall adjusted importance of the analyzed variables. The effect size was classified as small ($\eta_p^2 < 0.030$), medium ($0.030 \leq \eta_p^2 < 0.100$), or large ($\eta_p^2 \geq 0.100$).

The confidence level was set at 95% ($p \leq 0.05$).

3. Results

The co-creation results and the impact of the co-created intervention on school lunch participation and satisfaction, BMI, WHtR, and adherence to MDP are presented in this section.

The flow of participants can be seen in Figure 1.

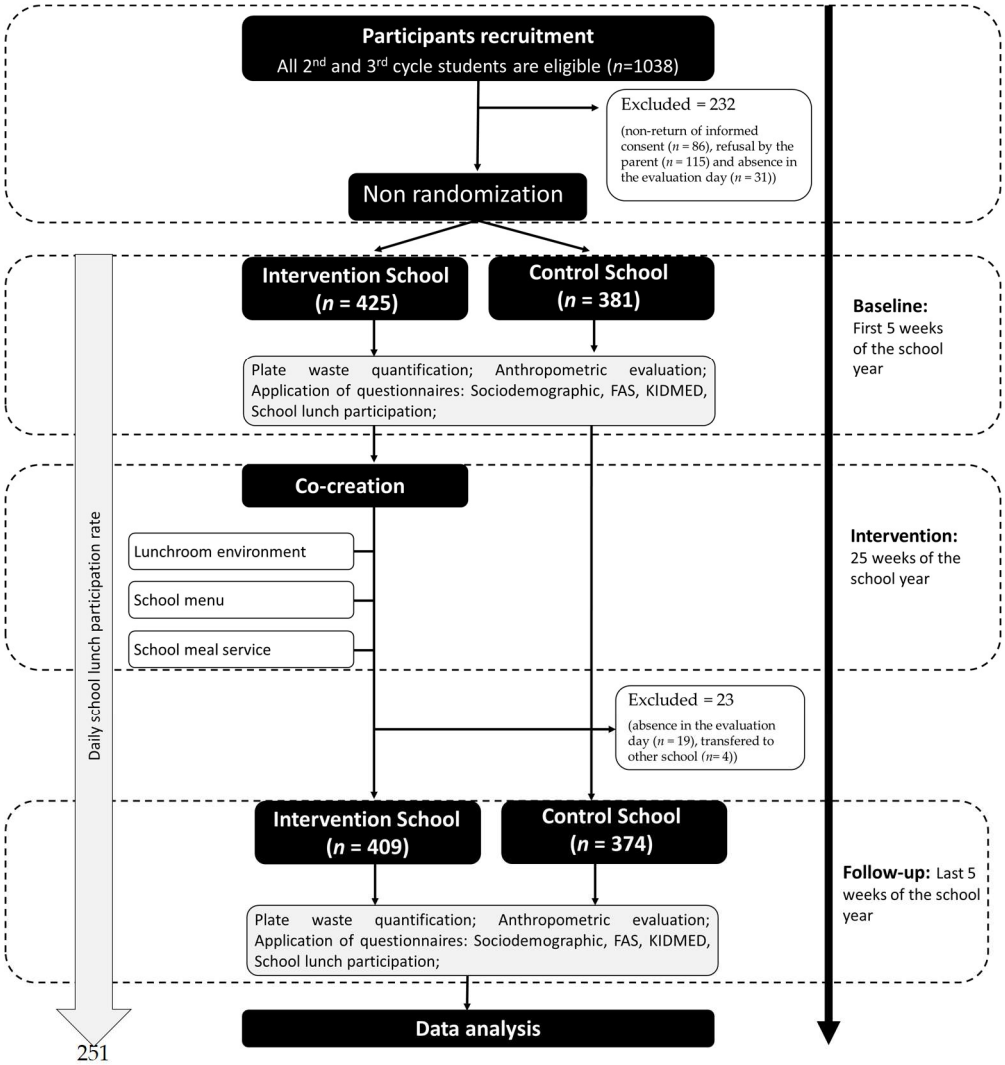

Figure 1. The flow of participants through each stage of the R23 study. FAS, Family Affluence Scale; KIDMED, Mediterranean Diet Quality Index.

3.1. Co-creation

In both workshops, participants were mainly female (workshop 1: n = 45 (53%); workshop 2: n = 10 (100%)), aged 10 to 55 years old, and consisted of 43 students, 5 parents, 4 teachers, 2 experts, and 1 councilwoman. Participants in workshop 1 were mainly student class delegates, and in workshop 2, parents and teachers.

In response to the question "*How might we redesign the food service to increase school lunch participation and satisfaction?*" we obtained more than 100 proposals. In Table 1, we

present a summary of what the co-creators considered important to increase school lunch participation and satisfaction and how the implementation took place.

Table 1. Co-creators proposals and implementation in intervention school.

Components	Proposals	Implementation
Lunchroom environment	Ambient music	Acquisition of equipment. Partnership with Radio school club who took the responsibility to play music every day during lunch hour.
	Renovation	School staff, teachers, and city employees were responsible for the renovation. Work was done during the break between semesters. The following work was done: wall, ceiling, and doors were painted and repaired, tables were painted in black, and one wall was painted with slate ink.
	Decoration	The rearrangement of the tables creates different socialization areas. Wall panels with messages and designs associated with food waste, the planetary health diet, and healthy eating. The design of the wall panels was made by a designer in collaboration with the students' association.
	Increase lunchroom area with the creation of a terrace	Acquisition of recycled plastic tables. Completed only at the end of the school year. An additional 48 seating places were created outside the lunchroom.
School menu	Filtered water	The taste of tap water was considered a problem. The solution was the installation of water filtration equipment which was done by the municipal water company. A partnership was established with this company also securing the maintenance of the equipment.
	Less healthy Mediterranean options	Although the co-creators recognized the importance of healthy food, they also wanted to have less healthy lunches sometimes, like lasagna, pizzas, or burgers. We considered this request and integrated these options into the menu, especially on commemorative days.
	Vegetarian taste tests	Although the vegetarian option already existed on the menu, student's adherence was almost nonexistent. This was because students did not know that this option was available and the ones that did know were afraid to try. They proposed taste tests offered to students who wanted to try to increase adherence to veggie meals.
	Creating a 3rd option in the menu	According to students' suggestions, a third option in the menu was created, named CoMtradição, adding to the Mediterranean and Veggie. This option is based on salads, sandwiches, or wraps and most times uses the same protein from the Mediterranean dish but is served differently. Thereby, the costs were controlled.
	Sweet desert once a week	Adding to fruit, always available, once a week a different dessert was served, like rice pudding, pudding, jelly, or fruit salad.
School meal service	Increasing canteen staff	Time waiting in line was a problem mentioned by all co-creators. To help decrease the time waiting in line one more person was employed.
	Salad bar	Having the autonomy to choose what to eat for the salad was a proposal agreed upon by all co-creators. A salad bar was created with four different vegetables (lettuce, tomatoes, cucumber, beets, carrot, or sweet corn), olive oil, vinegar, salt, and oregano. Students chose what they wanted for salad and seasoned it according to taste.
	Evaluation system	In the R23 a black slate wall was created where students can write their suggestions.
	Fruit kiosk	Outside the R23 a fruit kiosk was constructed. The school club "DoTamanhoDoMundo" designed and named the kiosk "Desfruta". Free fruit was available to all students, teachers, and school staff. Also, the lunch bread that was not consumed was made available in this kiosk, decreasing lunch food waste.

The students' association took the responsibility of renaming the canteen. The name proposed was R23. R from "**R**efeitório" (canteen) and **23** the year of the inauguration. R23 also became the name of the project. Before the inauguration, food service staff received

training to improve vegetarian cooking skills, food safety training, and client satisfaction management.

On the first day of the second semester, the R23 was inaugurated. All co-creators were invited to this event, as well as the school staff, school board, parents' association, students' association, and city council president.

Following this inauguration, a set of activities were put in place to promote the school lunch and R23 project: three vegetarian cooking workshops, sustainability education sessions (only 2 classes adhered to these sessions; n = 43), food waste quantification performed by students (1 class; n = 21) and celebration of special days, like children's day, with special menus.

All intervention stages were communicated through social media and local newspapers to reach all the school community members, especially parents and students.

3.2. Characteristics of the participants evaluated at follow-up

Baseline results and discussion can be seen elsewhere (Artigo 2).

There were no significant differences between excluded students (n = *23*) and those that completed the study (n = 783) for the main sociodemographic and socioeconomic characteristics: age (p=0.174); gender (p=0.205); grade (p=0.160); FAS (p=0.795) and FRPM status (p=0.183). From the 806 students at baseline, 23 were lost at follow-up, due to absence on the evaluation day (n = 19) and transfer to other schools (n = 4) (Figure 1). The participation rate at follow-up was 75.4%.

The sociodemographic and socioeconomic characteristics of the 783 students who completed the study can be seen in Table 2. There were no significant differences between the intervention school (n = 409) and the control school (n = 374) for gender, FAS, and eligibility to FRPM. On the contrary, age, grade, and nationality significantly differed between schools.

Table 2. Sociodemographic, socioeconomic characteristics of the participants at follow-up.

	Intervention school (n = 409)	**Control school** (n = 374)	**Total** (n = 783)	p
Age, mean years (SD)	12.1 (1.3)	11.5 (1.1)	11.8 (1.2)	**<0.001^{T*}**
Gender, n (%)				
Female	193 (47.2%)	170 (45.5%)	363 (46.4%)	0.667^{F}
Male	216 (52.8%)	204 (54.5%)	420 (53.6%)	
Grade, n (%)				
5th Grade	108 (26.4%)	143 (38.2%)	251 (32.1%)	
6th Grade	121 (29.6%)	170 45.5%)	291 (37.2%)	**<0.001^{MW*}**
7th Grade	90 (22.0%)	34 (9.1%)	124 (15.8%)	
8th Grade	90 (22.0%)	27 (7.2%)	117 (14.9%)	
Portuguese nationality, n (%)	372 (91.0%)	322 (86.1%)	694 (88.6%)	**0.003^{Q*}**
FAS, mean (SD)	7.4 (2.1)	7.2 (2.1)	7.3 (2.1)	0.253^{T}
Students eligible for FRPM, n (%)				
A - Free Price Meal	69 (16.9%)	57 (15.2%)	126 (16.1%)	
B - Half Price Meal	63 (15.4%)	69 (18.4%)	132 (16.9%)	0.850^{MW}
C - Full Price Meal	277 (67.7%)	248 (66.3%)	525 (67.0%)	

* Values of p<0.05 indicate that the schools differ about the analyzed variables; FAS – Family Affluence Scale; MW - Mann-Whitney *U* test; T –*t*-test; Q – Chi-square test; F – Fisher Exact test.

There is a considerable difference in the number of students in each grade, with more 5th and 6th graders in the control school (n = 313; 83.7%) than in the intervention school (n = 229; 56.0%).

One-third of students from both schools are entitled to FRPM (n = 258; 33.0%). Most students have Portuguese nationality (n = 694; 88.6%), with a significantly higher prevalence in the intervention school.

3.3. Impact of the co-created intervention on school lunch participation

In Table 3, we can observe a significant increase in participation rates in the intervention school for adults, teachers, and school staff (4.3pp; p<0.001), students (5.3pp; p<0.001), 2nd (4.8pp; p<0.001) and 3rd (5.6pp; p<0.001) cycle students and students without FRPM status (4.5pp; p<0.001). On the other hand, the control school had a significant decrease in student participation rates eligible for FRPM (-6.8pp; p=0.009; -6.2pp; p=0.009) and an increase in PR for 3rd cycle students (4.0pp; p=0.016). Overall, a decrease in students' school lunch PR was observed in the control school, although not significant (-3.3pp; p=0.116).

Table 3. Average school lunch participation rate in intervention and control schools at baseline and follow-up.

	Intervention School (IS) (n = 409)				**Control school (CS)** (n = 374)			
	Baseline % (SD)	**Follow-up** % (SD)	**Δ** pp	**Within-group analysis p-value**	**Baseline** % (SD)	**Follow-up** % (SD)	**Δ** pp	**Within-group analysis p-value**
PR Adults	1.1% (1.1)	5.4% (3.0)	4.3	**<0.001^{T*}**	3.2% (2.4)	3.9% (2.0)	0.7	0.265
PR Students	22.1% (2.8)	27.4% (3.4)	5.3	**<0.001^{T*}**	28.5% (7.3)	25.2% (7.3)	-3.3	0.116
PR according to cycle								
PR 2nd cycle	24.9% (3.0)	29.8% (3.3)	4.8	**<0.001^{T*}**	28.3% (9.9)	25.7% (9.5)	-2.6	0.355
PR 3rd cycle	18.5% (3.8)	24.1% (4.8)	5.6	**<0.001^{T*}**	20.1% (5.4)	24.1% (5.8)	4.0	**0.016^{T*}**
PR according to FRPM eligibility								
PR_A	46.8% (6.6)	48.1% (6.2)	1.3	0.487	41.8% (9.2)	35.0% (8.7)	-6.8	**0.009^{T*}**
PR_B	25.6% (4.9)	27.5% (4.2)	1.9	0.140	27.1% (8.4)	20.9% (7.7)	-6.2	**0.009^{T*}**
PR_C	16.2% (2.4)	20.7% (2.9)	4.5	**<0.001^{T*}**	25.9% (7.1)	23.4% (7.1)	-2.5	0.229

* Values of p<0.05 indicate that there are differences between baseline and follow-up for the analyzed variables; T – t-test; Δ - Follow-up – Baseline difference = percentage point (pp); PR – Participation Rate; PR_A – Participation Rate of students eligible for Free Price Meals; PR_B – Participation Rate of students eligible for Half Price Meals; PR_C – Participation Rate of students paying Full Price Meals.

Throughout the school year, students' PR increased significantly in the intervention school (r^P= 0.558; p<0.001). On the contrary, we did not find a significant association in the control school (r^P= -0.110; p=0.232).

Similar results were found in the average weekly school lunch participation reported by students in the questionnaire. In intervention school, there was a significant increase in the average weekly school lunch participation reported by students and a decrease in non-participation (-9.5pp) between baseline and follow-up. Of notice is a significant increase of 4.5 percentage points in partial adherence and 5.1 percentage points in effective adherence in intervention school. On the contrary, the control school presented no significant difference between baseline and follow-up (p=0.055) (Table 4).

General Linear Model (GLM) analysis, adjusted for age, gender, grade, FAS, and FRPM, showed that there was a significant impact of the co-created intervention on the average weekly school lunch participation between baseline and follow-up (p<0.001).

Table 4. School lunch participation reported by students in intervention and control schools at baseline and follow-up.

	Intervention school (IS) (n = 409)				Control school (CS) (n = 374)				p^a	
	Baseline n (%)	**Follow-up** n (%)	**Δ** pp	p	**Baseline** n (%)	**Follow-up** n (%)	**Δ** pp	p	t	$I \times t$
Non-adherence										
0 times/week	**221 (54.0%)**	**182 (44.5%)**	**-9.5**		**82 (21.9%)**	**104 (27.8%)**	**5.9**			
Partial adherence	**123 (30.0%)**	**141 (34.5%)**	**4.5**		**173 (46.3%)**	**162 (43.3%)**	**-3.0**			
1 times/week	50 (12.2%)	53 (13.0%)	0.8		128 (34.2%)	97 (25.9%)	-8.3			
2 times/week	28 (6.8%)	41 (10.0%)	3.2	**<0.001^{T*}**	37 (9.9%)	47 (12.6%)	2.7	0.055	0.155	**<0.001^{T*}**
3 times/week	45 (11.0%)	47 (11.5%)	0.5		8 (2.1%)	18 (4.8%)	2.7			
Effective adherence	**65 (15.9%)**	**86 (21.0%)**	**5.1**		**119 (31.8%)**	**108 (28.9%)**	**-2.9**			
4 times/week	9 (2.2%)	11 (2.7%)	0.5		5 (1.3%)	13 (3.5%)	2.2			
5 times/week	56 (13.7%)	75 (18.3%)	4.6		114 (30.5%)	95 (25.4%)	-5.1			

* Values of p<0.05 indicate that there are differences between baseline and follow-up for the analyzed variables; T – t-test; Δ - Follow-up – Baseline difference = percentage point (pp); [a] GLM repeated measures: t - time effect; I*t - Intervention and time interaction; Model was adjusted for age, gender, grade, FAS and FRPM.

3.4. Impact of the co-created intervention on school lunch satisfaction

At baseline, the daily menus were the same in both schools; however, at follow-up, the menu was the same except for including a third option in the menu of the intervention school. The menu was different at baseline and follow-up.

Overall, plate waste was significantly reduced in both schools (Table 5). Intervention and control school plate waste decreased significantly between baseline and follow-up.

Table 5. Plate waste index resulting from 8 nonconsecutive days quantification at baseline and follow-up.

	Intervention school (IS)				Control school (CS)				p^a		
	Baseline (n = 8)	**Follow-up** (n = 8)	**Δ** pp	p	**Baseline** (n = 8)	**Follow-up** (n = 8)	**Δ** pp	p	t	$I \times C$	$I \times t$
Total no. lunches	1097	1120	23		1209	1099	-110				
PW, mean % (SD)											
Complete lunch	24.1% (5.25)	18.9% (5.80)	-5,2	**0.046^{MW*}**	33.7% (10.98)	24.0% (5.71)	-9.7	**0.049^{T*}**	**0.007***	**0.008***	0.391
Soup	22.9% (7.78)	20.6% (6.51)	-2,3	0.536	31.5% (7.20)	24.2% (5.60)	-7.3	**0.042^{T*}**	0.059	**0.017***	0.314
Main dish	24.7% (9.21)	19.5% (8,22)	-5,2	0.266	34.7% (14.48)	25.9% (9.04)	-8.8	0.168	0.074	**0.037***	0.635
Vegetables	24.8% (6.06)	11.6% (3.66)	-13.2	**<0.001***	27.5% (9.45)	14.9% (5.38)	-12.6	**0.019^{MW*}**	**<0.001***	0.215	0.907

* Values of p<0.05 indicate that there are differences between baseline and follow-up for the analyzed variables; T – t-test; MW - Mann-Whitney U test; Δ - Follow-up – Baseline difference; pp – percentage points; PW, Plate Waste; [a] GLM univariate: t - time effect; I*C – Intervention and control school interaction; I*t - Intervention and time interaction.

Plate waste for complete lunch significantly decreased between baseline and follow-up (p=0.007), in control and intervention schools (p=0.008). Still, variation at follow-up is not different between schools (p=0.391), suggesting that the intervention did not impact plate waste reduction or school lunch satisfaction.

3.5. Impact of the co-created intervention on BMI, WHtR, and adherence to MDP

At follow-up, both schools showed a significant decrease in BMI z-scores (-0.11 and -0.12 in IS and CS, respectively), prevalence of students at increased risk of cardiovascular disease (WHtR≥ 0.5) (-3.1% and -2.4% in IS and CS, respectively) and an increase in the adherence to MDP (0.8 and 0.7 in IS and CS, respectively). However, the impact of the co-created intervention was only significant in WHtR (p<0.001), with a small effect size (η_p^2 = 0.019), indicating that the intervention had an impact on the reduction of WHtR, i.e., decreased number of students with increased risk of cardiovascular disease (Table 6).

Table 6. Impact of the co-created intervention on BMI, WHtR, and KIDMED in intervention and control schools.

	Intervention school (IS) (n = 409)				**Control school (CS)** (n = 374)				p^a (η_p^2)	
	Baseline	**Follow-up**	**Δ**	***p***	**Baseline**	**Follow-up**	**Δ**	***p***	***t***	***I x t***
BMI age-z-score (SD)	0.58 (1.37)	0.47 (1.30)	-0.11	**<0.001^{T*}**	0.59 (1.28)	0.47 (1.26)	-0.12	**<0.001^{T*}**	**0.005***	0.375 (0.001)
Thinness, *n* (%)	11 (2.7%)	8 (2.0%)	-0.7		9 (2.4%)	9 (2.4%)	0			
Normal body weight, *n* (%)	231 (56.5%)	255 (62.3%)	5.8	**<0,001^{W*}**	222 (59.4%)	233 (62.3%)	2.9	**0.006^{W*}**		
Overweight, *n* (%)	97 (23.7%)	87 (21.3%)	-2.4		88 (23.5%)	86 (23.0%)	0.5			
Obesity, *n* (%)	70 (17.1%)	59 (14.4%)	-2.7		55 (14.7%)	46 (12.3%)	-2.4			
WHtR	0.428 (0.06)	0.437 (0.06)	0.01		0.431 (0.05)	0.426 (0.05)	0.01		**<0.001***	**<0.001*** (0.019)
≥ 0.5, *n* (%)	64 (15.6%)	51 (12.5%)	-3.1	**<0.001^{F*}**	43 (11.5%)	34 (9.1%)	-2.4	**<0.001^{F*}**		
KIDMED score (SD)	6.07 (2.37)	6.87 (2.28)	0.8	**<0.001^{T*}**	6.22 (2.37)	6.92 (2.43)	0.7	**<0.001^{T*}**	0.216	0.534 (0.001)
Low adherence, *n* (%)	62 (15.2%)	41 (10.0%)	-5.2		47 (12.6%)	32 (8.6%)	-4.0			
Moderate adherence, *n* (%)	230 (56.2%)	195 (47.7%)	-8.5	**<0.001^{W*}**	218 (58.3%)	181 (48.4%)	-9.9	**<0.001^{W*}**		
High adherence, *n* (%)	117 (28.6%)	173 (42.3%)	13.7		108 (28.9%)	160 (42.8%)	13.9			

* Values of p<0.05 indicate that there is impact about the analyzed variables; pp – percentage points; T – *t*-test; F – Fisher Exact test; W – Wilcoxon test; [a] GLM repeated measures: t - time effect; I*t - Intervention and time interaction; η_p^2 = Partial eta squared.

4. Discussion

4.1. Impact of the co-created intervention on school lunch participation and satisfaction

Successful results were achieved after the implementation of the co-created intervention. Implementing the co-creator's proposals, i.e., redesigning the lunchroom, menu, and meal service, led to a significant increase in students' school lunch participation, from 22.1% to 27.4%, representing a 24.0% increase. Increases in participation were significantly higher among students without FRPM status. Furthermore, effective adherence to school lunch was also significant, increasing by 5.1 percentage points. Interestingly, the R23 project also impacted adults' (teachers and school staff) participation rates from 1.1% to 5.4%, representing a 491% growth.

Only one recent study, with a quasi-experimental design, was found in the literature, aiming to increase school lunch participation [34]. Several strategies were used in this study: cafeteria redesign, increasing school lunch point-of-sale, and teacher education, which resulted in a modest but significant relative increase in participation [34]. The authors chose these components considering results published by other researchers [27,28,58,59]. The innovation in our study that could explain the most remarkable success was co-creating the intervention with the school community. This was a bottom-up approach, i.e., the school community proposed which modifications would be important to

implement in the menu, lunchroom, and meal service so the school lunch participation increased. The R23 design aimed to promote an effective alignment of the intervention with Benavente students' wishes and attitudes, hoping to overcome barriers to participation by constructing a food school service tailored to their specific needs and views.

While the intervention significantly impacted the school lunch participation outcome the same did not occur with satisfaction evaluated through plate waste quantification. Plate waste reduction was observed in both schools. However, we cannot attribute this reduction to the intervention. The fact that the menu differed at baseline and follow-up can justify this result. Of notice was also a significant reduction in vegetable plate waste in the intervention school. The implementation of a salad bar could lead to an increase in plate waste; however, that was not observed, suggesting that this is a good option to include in all schools.

Our results also showed high values of plate waste even after the intervention (18.9% and 24.0% in IS and CS, respectively), much higher than 10%, a value considered acceptable by some authors [60]. Other studies performed in Portugal also had plate waste higher than 10%, with an average plate waste index of 17% [30] and 18% [61]. Plate waste quantification is a way to assess meal satisfaction [33,46]. However, other factors can be responsible for these high values, such as portion inadequacy to students' nutritional needs [62], insufficient time to eat, appetite, and the availability of competitive foods [63].

4.2. Impact of the co-created intervention on BMI, WHtR, and the adherence to MDP

A decrease in obesity rates was observed in both schools, with better results in the intervention school, where the prevalence of overweight was 21.36% and obesity was 14.4%. However, the intervention did not produce a significant impact on this outcome. This result is consistent with other studies reviewed recently, where most intervention studies had little or no impact on the BMI of children [64]. The ineffectiveness of most intervention studies may be explained by intervention duration [65]. One year may not be enough to observe an impact on children's weight status. Moreover, it is essential to recognize that obesity is a complex chronic disease with multiple determinants, and a single intervention is not likely to prevent childhood obesity [66,67]. Although R23 had minimal non-significant effects on BMI, this project can be important in an overall strategy to fight the obesity epidemic in Benavente Municipality [68].

In contrast, the co-created intervention significantly impacted the reduction of the prevalence of students with increased risk of cardiovascular disease by reducing central adiposity (-3.1pp and -2.4pp in IS and CS, respectively). According to some authors, WHtR may be a better early predictor of cardiovascular and chronic disease [69], as BMI fails to identify more than a quarter of children with excess body fat percentage [70]. In this study, we found a significant impact of the intervention on WHtR, while in BMI the effect was not significant. Including WHtR outcomes in intervention projects could help researchers better evaluate the effect on child obesity.

Adherence to MDP increased significantly in both schools, with a higher increase in KIDMED scores in the intervention school. However, the intervention is not the only responsible for this result. In a previous paper describing baseline results of the R23 project, published by these authors, an association between adherence to MDP and school lunch participation was observed (Artigo 2). However, the R23 intervention did not significantly improve students' adherence to MDP. This may be explained by the fact that the increase in school lunch participation, although significant, was not enough to affect the adherence to MDP.

4.3. Study strengths and limitations

To the best of our knowledge, this is the first study in Portugal with a quasi-experimental design, and a bottom-up school-based co-created intervention, aiming to increase

school lunch participation and satisfaction and subsequently expecting to contribute to healthier food habits and body weight. The innovation brought by the R23 project was the co-created intervention with the school community and the significant implementation of the ideas presented in the co-creation process. This translation into practice led to increased trust in the school food service significantly increasing school lunch participation rates.

R23 was a multi-component co-created intervention, and by design, we cannot infer which components were more relevant for the impacts observed. However, due to the steady increase in the consumption of the 3rd menu option throughout intervention and follow-up (data not presented), we can assume that this change in the menu was important for the students.

Some limitations should be mentioned. While the randomization of the schools would allow for more robust conclusions, in Benavente's case, this was not possible because the intervention school urgently needed construction work in the kitchen and lunchroom. The selection bias that can result from a lack of randomization was minimized using statistical methods to adjust for potentially confounding effects, like multivariate analysis.

School lunch satisfaction was evaluated through plate waste quantification at baseline and follow-up. Two limitations can be stated: the number of quantification days may be too low and the menu differed between these two time points.

The duration of the study can also be a limitation. A study with a more extended period may be needed to capture the impact of increased school lunch participation on BMI, WHTR, and KIDMED [65]. The significant decrease in BMI and increase in KIDMED scores in both schools can result from seasonal variations of these outcomes [71]. Weight gain and diet in children are not consistent throughout the year. Several studies pointed out that children's BMI increases more during summer holidays compared to other periods of the year [72,73]. Baseline data were collected at the beginning of the school year when the effect of sedentary activities and excessive snacking during summer break could still be reflected in BMI. On the other hand, the structured days hypothesis [74], theorizes that the structured nature of the school day, with physical education classes and limited opportunities to eat, helps students maintain a healthy body weight [72]. This could explain why follow-up measurements improved significantly for BMI and KIDMED scores.

Finally, the face-to-face interviewer-administered questionnaire allowed the recording of more accurate answers, increased the response rate, and ensured that all questions were answered. However, this type of questionnaire can produce interviewer bias [75].

4.4. Future directions

Although R23 significantly increased school lunch participation, the average number of students who ate at the school canteen daily remained low (27.4%). Besides the necessity of a more extended intervention, more work is needed to understand what additional changes can be implemented to have the majority of students eating lunch at school. Some have already been pointed out by other authors [76]. Improving the convenience of school lunches is considered a promising strategy to increase participation and satisfaction [77]. In the future, implementing a Grab-and-go system in the R23 to reduce waiting in line and improve convenience will be proposed to the school community. Also, universal free school lunches have been shown in several studies to increase participation rates [78]. This can also be an option to consider in the future.

Increasing participation rates is only the first step towards improving students' diet and nutritional status. In parallel, we should also pursue implementing strategies to increase school lunch consumption and reduce plate waste so that all nutritional value of meals is fully used.

5. Conclusions

This innovative study provided evidence of the effectiveness of co-created interventions in increasing school lunch participation and further impacting the reduction of the prevalence of students with increased risk of cardiovascular disease. The R23 study added value to the Benavente school food service, recognized by the main stakeholders, students, but also by teachers, parents, and school staff.

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References

1. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* **2019**, *393*, 447-492.
2. Clark, M.; Springmann, M.; Rayner, M.; Scarborough, P.; Hill, J.; Tilman, D.; Macdiarmid, J.I.; Fanzo, J.; Bandy, L.; Harrington, R.A. Estimating the environmental impacts of 57,000 food products. *Proceedings of the National Academy of Sciences* **2022**, *119*, e2120584119.
3. Clark, M.A.; Springmann, M.; Hill, J.; Tilman, D. Multiple health and environmental impacts of foods. *Proc Natl Acad Sci U S A* **2019**, *116*, 23357-23362.
4. IPCC. Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, (in press). **2023**.
5. Rippin, H.L.; Cade, J.E.; Berrang-Ford, L.; Benton, T.G.; Hancock, N.; Greenwood, D.C. Variations in greenhouse gas emissions of individual diets: Associations between the greenhouse gas emissions and nutrient intake in the United Kingdom. *Plos one* **2021**, *16*.
6. Collaboration, N.R.F. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet* **2017**, *390*.
7. Lopes, C.; Torres, D.; Oliveira, A.; Severo, M.; Alarcão, V.; Guiomar, S.; Mota, J.; Teixeira, P.; Rodrigues, S.; Lobato, L. Inquérito Alimentar Nacional e de Atividade Física IAN-AF 2015-2016: relatório de resultados. **2017**.
8. World Health, O. *A primary health care approach to obesity prevention and management in children and adolescents: policy brief*; World Health Organization: Geneva, 2023.

9. Direção-Geral da Saúde. Programa Nacional para a Promoção da Alimentação Saudável 2022-2030. **2022**.
10. Álvares, L.; Amaral, T.F. Food Insecurity and Associated Factors in the Portuguese Population. *Food and Nutrition Bulletin* **2014**, *35*, S395-S402.
11. Maia, I.; Santos, A.C. Prevalence and determinants of children self-reports of food insecurity: evidence from a Portuguese population-based birth cohort. *Food Security* **2022**, *14*, 427-435.
12. Oostindjer, M.; Aschemann-Witzel, J.; Wang, Q.; Skuland, S.E.; Egelandsdal, B.; Amdam, G.V.; Schjoll, A.; Pachucki, M.C.; Rozin, P.; Stein, J.; et al. Are school meals a viable and sustainable tool to improve the healthiness and sustainability of children's diet and food consumption? A cross-national comparative perspective. *Critical Reviews in Food Science and Nutrition* **2017**, *57*, 3942-3958.
13. O'Connell, R.; Brannen, J. *Families and food in hard times: European comparative research*; UCL Press: 2021.
14. Castro-Mendes, F.d.; Cunha, P.; Paciência, I.; Rufo, J.C.; Farraia, M.; Silva, D.; Padrão, P.; Delgado, L.; Moreira, A.; Moreira, P. The Influence of Eating at Home on Dietary Diversity and Airway Inflammation in Portuguese School-Aged Children. *International Journal of Environmental Research and Public Health* **2021**, *18*.
15. Au, L.E.; Rosen, N.J.; Fenton, K.; Hecht, K.; Ritchie, L.D. Eating School Lunch Is Associated with Higher Diet Quality among Elementary School Students. *J Acad Nutr Diet* **2016**, *116*, 1817-1824.
16. Kinderknecht, K.; Harris, C.; Jones-Smith, J. Association of the Healthy, Hunger-Free Kids Act With Dietary Quality Among Children in the US National School Lunch Program. *JAMA* **2020**, *324*, 359-368.
17. Moreira, T.; Severo, M.; Oliveira, A.; Ramos, E.; Rodrigues, S.; Lopes, C. Eating out of home and dietary adequacy in preschool children. *Br J Nutr* **2015**, *114*, 297-305.
18. Assembleia da República. Lei n.º 34/2019. *Diário da República, Série I*, 2544 - 2546.
19. Assembleia da República. Lei n.º 11/2017. *Diário da República, Série I*, 1974 - 1974.
20. Parlamento Europeu e do Conselho. Regulamento (CE) n.° 178/2002. *Jornal Oficial nº L 031*, 0001-0024.
21. Parlamento Europeu e do Conselho. Regulamento (CE) n.° 852/2004. *Jornal Oficial nº L 139*, 0001-0023.
22. Ministério da Educação - Gabinete da Secretária de Estado Adjunta e da Educação. Despacho n.º 8127/2021. *Diário da República Série-II*, 44 - 49.
23. Presidência do Conselho de Ministros. Resolução do Conselho de Ministros n.º 132/2021. *Diário da República Série-I*, 10-46.
24. Finanças, A.I., Educação, Saúde, Economia, Agricultura, Florestas, Desenvolvimento Rural e Mar,. Despacho n.º 11418/2017. *Diário da República Série-II*, 29595-29598.
25. Direção-Geral da Educação. Circular nº.: 3097/DGE/2018. *Orientações sobre ementas e refeitórios escolares* **2018-08-08**.
26. Madeira, B.M.C. Adesão aos refeitórios escolares no 2º, 3º ciclos e ensino secundário. Instituto Superior de Ciências da Saúde Egas Moniz, 2014.
27. Payán, D.D.; Sloane, D.C.; Illum, J.; Farris, T.; Lewis, L.B. Perceived barriers and facilitators to healthy eating and school lunch meals among adolescents: A qualitative study. *American journal of health behavior* **2017**, *41*, 661-669.
28. Meiselman, H.L.; Johnson, J.L.; Reeve, W.; Crouch, J.E. Demonstrations of the influence of the eating environment on food acceptance. *Appetite* **2000**, *35*, 231-237.
29. Fox, M.K.; Gearan, E.; Cabili, C.; Dotter, D.; Niland, K.; Washburn, L.; Paxton, N.; Olsho, L.; LeClair, L.; Tran, V. *School Nutrition and Meal Cost Study final report volume 4: Student participation, satisfaction, plate waste, and dietary intakes*; Mathematica Policy Research: 2019.
30. Moreira, P.; Ávila, H.; Correia, M.J. Quantificação do desperdício alimentar em refeitórios escolares: impacto de uma campanha de sensibilização. *Acta Portuguesa de Nutrição* **2021**, *24*, 38-45.

31. Bailey-Davis, L.; Virus, A.; McCoy, T.A.; Wojtanowski, A.; Vander Veur, S.S.; Foster, G.D. Middle School Student and Parent Perceptions of Government-Sponsored Free School Breakfast and Consumption: A Qualitative Inquiry in an Urban Setting. *Journal of the Academy of Nutrition and Dietetics* **2013**, *113*, 251-257.
32. Mirtcheva, D.M.; Powell, L.M. Participation in the National School Lunch Program: Importance of School-Level and Neighborhood Contextual Factors. *Journal of School Health* **2009**, *79*, 485-494.
33. Fox, M.; Gearan, E.; Cabili, C.; Dotter, D.; Niland, K.; Washburn, L.; Paxton, N.; Olsho, L.; LeClair, L.; Tran, V. Student participation, satisfaction, plate waste, and dietary intakes. *School Nutrition and Meal Cost Study* **2019**, *4*.
34. Thompson, H.R.; Gosliner, W.; Ritchie, L.; Wobbekind, K.; Reed, A.L.; O'Keefe, O.; Madsen, K.A. The Impact of a Multipronged Intervention to Increase School Lunch Participation among Secondary School Students in an Urban Public School District. *Child Obes* **2020**, *16*, S14-s22.
35. Lülfs-Baden, F.; Rojas-Méndez, J.I.; Spiller, A. Young consumers' evaluation of school meals. *Journal of International Food & Agribusiness Marketing* **2008**, *20*, 25-57.
36. Leask, C.F.; Sandlund, M.; Skelton, D.A.; Altenburg, T.M.; Cardon, G.; Chinapaw, M.J.M.; De Bourdeaudhuij, I.; Verloigne, M.; Chastin, S.F.M. Framework, principles and recommendations for utilising participatory methodologies in the co-creation and evaluation of public health interventions. *Res Involv Engagem* **2019**, *5*, 2.
37. Sanders, E.B.-N.; Stappers, P.J. Co-creation and the new landscapes of design. *Co-design* **2008**, *4*, 5-18.
38. Tay, B.S.J.; Cox, D.N.; Brinkworth, G.D.; Davis, A.; Edney, S.M.; Gwilt, I.; Ryan, J.C. Co-Design Practices in Diet and Nutrition Research: An Integrative Review. *Nutrients* **2021**, *13*, 3593.
39. Tay, B.S.J.; Edney, S.M.; Brinkworth, G.D.; Cox, D.N.; Wiggins, B.; Davis, A.; Gwilt, I.; Haveman-Nies, A.; Ryan, J.C. Co-design of a digital dietary intervention for adults at risk of type 2 diabetes. *BMC Public Health* **2021**, *21*, 2071.
40. Anselma, M.; Altenburg, T.M.; Emke, H.; van Nassau, F.; Jurg, M.; Ruiter, R.A.C.; Jurkowski, J.M.; Chinapaw, M.J.M. Co-designing obesity prevention interventions together with children: intervention mapping meets youth-led participatory action research. *International Journal of Behavioral Nutrition and Physical Activity* **2019**, *16*, 130.
41. Carins, J.; Bogomolova, S. Co-designing a community-wide approach to encouraging healthier food choices. *Appetite* **2021**, *162*, 105167.
42. Haynes, A.B.; Haukoos, J.S.; Dimick, J.B. TREND Reporting Guidelines for Nonrandomized/Quasi-Experimental Study Designs. *JAMA Surgery* **2021**, *156*, 879-880.
43. Inchley, J.; Currie, D.; Cosma, A.; Samdal, O. Health behaviour in school-aged children (HBSC) study protocol: background, methodology and mandatory items for the 2017/18 survey. St Andrews: CAHRU. **2018**.
44. Hartley, J.E.K.; Levin, K.; Currie, C. A new version of the HBSC Family Affluence Scale - FAS III: Scottish Qualitative Findings from the International FAS Development Study. *Child Indic Res* **2016**, *9*, 233-245.
45. Sturion, G.L.; Silva, M.V.d.; Ometto, A.M.H.; Furtuoso, M.C.O.; Pipitone, M.A.P. Fatores condicionantes da adesão dos alunos ao Programa de Alimentação Escolar no Brasil. *Revista de Nutrição* **2005**, *18*, 167-181.
46. Ferreira, M.; Martins, M.L.; Rocha, A. Food waste as an index of foodservice quality. *British Food Journal* **2013**.
47. Comstock, E.M.; St Pierre, R.G.; Mackiernan, Y.D. Measuring individual plate waste in school lunches. Visual estimation and children's ratings vs. actual weighing of plate waste. *J Am Diet Assoc* **1981**, *79*, 290-296.
48. Liz Martins, M.; Cunha, L.M.; Rodrigues, S.S.; Rocha, A. Determination of plate waste in primary school lunches by weighing and visual estimation methods: a validation study. *Waste Manag* **2014**, *34*, 1362-1368.
49. Stewart, A.; Marfell-Jones, M.; Olds, T.; De Ridder, J. *International Standards for Anthropometric Assessment*; International Society for the Advancement of Kinanthropometry: 2011; Volume 137.
50. World Health Organization. WHO AnthroPlus for personal computers manual: software for assessing growth of the world's children and adolescents. *Geneva: WHO* **2009**.

51. Onis, M.d.; Onyango, A.W.; Borghi, E.; Siyam, A.; Nishida, C.; Siekmann, J. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World health Organization* **2007**, *85*, 660-667.
52. Ashwell, M.; Gibson, S. Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix' based on BMI and waist circumference. *BMJ Open* **2016**, *6*, e010159.
53. Browning, L.M.; Hsieh, S.D.; Ashwell, M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. *Nutr Res Rev* **2010**, *23*, 247-269.
54. Serra-Majem, L.; Ribas, L.; Ngo, J.; Ortega, R.M.; García, A.; Pérez-Rodrigo, C.; Aranceta, J. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutr* **2004**, *7*, 931-935.
55. Rei, M.; Severo, M.; Rodrigues, S. Reproducibility and validity of the Mediterranean Diet Quality Index (KIDMED Index) in a sample of Portuguese adolescents. *Br. J. Nutr.* **2021**, *126*, 1737-1748.
56. Field, A. *Discovering statistics using IBM SPSS statistics*; sage: 2009.
57. Cohen, J. *Statistical power analysis for the behavioral sciences*; Academic press: 2013.
58. Olsta, J. Bringing breakfast to our students: a program to increase school breakfast participation. *The Journal of School Nursing* **2013**, *29*, 263-270.
59. Schwartz, M.B. The influence of a verbal prompt on school lunch fruit consumption: a pilot study. *International Journal of Behavioral Nutrition and Physical Activity* **2007**, *4*, 1-5.
60. Hospitality, N. Managing food waste in the NHS. *Leeds, UK: Department of Health* **2005**.
61. da Silva, B.; Teixeira, B.; Ávila, H.; Afonso, C. Avaliação do desperdício alimentar da refeição almoço em duas escolas públicas do distrito de Aveiro. *Acta Portuguesa de Nutrição* **2020**.
62. Martins, M.L.; Rodrigues, S.S.P.; Cunha, L.M.; Rocha, A. Strategies to reduce plate waste in primary schools - experimental evaluation. *Public Health Nutrition* **2016**, *19*, 1517-1525.
63. Cordingley, F.; Reeve, S.; Stephenson, J. Food Waste in Schools–Final Report. *Waste and Resources Action Programme (WRAP)* **2011**, *21*.
64. Pereira, A.R.; Oliveira, A. Dietary Interventions to Prevent Childhood Obesity: A Literature Review. *Nutrients* **2021**, *13*.
65. Chaudhary, A.; Sudzina, F.; Mikkelsen, B.E. Promoting Healthy Eating among Young People—A Review of the Evidence of the Impact of School-Based Interventions. *Nutrients* **2020**, *12*, 2894.
66. Gortmaker, S.L.; Swinburn, B.A.; Levy, D.; Carter, R.; Mabry, P.L.; Finegood, D.T.; Huang, T.; Marsh, T.; Moodie, M.L. Changing the future of obesity: science, policy, and action. *The Lancet* **2011**, *378*, 838-847.
67. Karnik, S.; Kanekar, A. Childhood obesity: A global public health crisis. *International Journal of Preventive Medicine* **2012**, *3*, 1-7.
68. Organization, W.H. Population-based approaches to childhood obesity prevention. **2012**.
69. Centeio, E.E.; McCaughtry, N.; Moore, E.W.G.; Kulik, N.; Garn, A.; Martin, J.; Shen, B.; Somers, C.L.; Fahlman, M. Building healthy communities: A comprehensive school health program to prevent obesity in elementary schools. *Preventive Medicine* **2018**, *111*, 210-215.
70. Javed, A.; Jumean, M.; Murad, M.H.; Okorodudu, D.; Kumar, S.; Somers, V.; Sochor, O.; Lopez‐Jimenez, F. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta‐analysis. *Pediatric obesity* **2015**, *10*, 234-244.
71. Kucukerdonmez, O.; Rakıcıoglu, N. The effect of seasonal variations on food consumption, dietary habits, anthropometric measurements and serum vitamin levels of university students. *Prog Nutr* **2018**, *20*, 165-175.
72. Von Hippel, P.T.; Powell, B.; Downey, D.B.; Rowland, N.J. The effect of school on overweight in childhood: gain in body mass index during the school year and during summer vacation. *American journal of public health* **2007**, *97*, 696-702.

73. Moreno, J.P.; Johnston, C.A.; Woehler, D. Changes in weight over the school year and summer vacation: results of a 5 - year longitudinal study. *Journal of School Health* **2013**, *83*, 473-477.

74. Brazendale, K.; Beets, M.W.; Weaver, R.G.; Pate, R.R.; Turner-McGrievy, G.M.; Kaczynski, A.T.; Chandler, J.L.; Bohnert, A.; von Hippel, P.T. Understanding differences between summer vs. school obesogenic behaviors of children: the structured days hypothesis. *International Journal of Behavioral Nutrition and Physical Activity* **2017**, *14*, 1-14.

75. Cook, C. Mode of administration bias. *J Man Manip Ther* **2010**, *18*, 61-63.

76. Hecht, A.A.; Olarte, D.A.; McLoughlin, G.M.; Cohen, J.F.W. Strategies to Increase Student Participation in School Meals in the United States: A Systematic Review. *J Acad Nutr Diet* **2023**.

77. Machado, S.; Ritchie, L.; Thompson, H.; Reed, A.; Castro, A.I.; Neelon, M.; Madsen, K. Multi-pronged intervention to increase secondary student participation in school lunch: Design and rationale. *Contemporary Clinical Trials* **2019**, *78*, 133-139.

78. Cohen, J.F.W.; Hecht, A.A.; McLoughlin, G.M.; Turner, L.; Schwartz, M.B. Universal School Meals and Associations with Student Participation, Attendance, Academic Performance, Diet Quality, Food Security, and Body Mass Index: A Systematic Review. *Nutrients* **2021**, *13*, 911.

4 CONCLUSÕES

Os resultados deste estudo e respetiva discussão estão descritos nos artigos apresentados nesta tese. No entanto, tecemos aqui algumas considerações finais que merecem ser salientadas.

4.1 PRINCIPAIS RESULTADOS

Este estudo confirma que alterações ao ambiente alimentar escolar, cocriadas com a comunidade escolar, têm efeito significativo na adesão ao refeitório. Aumentar a adesão ao refeitório era o principal objetivo do projeto R23 que foi atingido com sucesso com um aumento de 24% na escola de intervenção. Esta abordagem *bottom-up* foi responsável por uma mudança na perceção negativa que os refeitórios escolares tinham até então que ficou evidenciado na adesão mas também no interesse da comunicação social local pelo projeto.

A intervenção cocriada teve também um impacto significativo no *outcome* razão perímetro da cintura estatura (WHtR), traduzindo-se numa diminuição significativa da prevalência de alunos com risco aumentado de doença cardiovascular.

Existe evidência científica de que as refeições escolares podem ser uma forma de lutar contra a obesidade infantil, daí constituir o foco em muitas das medidas que têm sido implementadas ao longo das últimas décadas na área da promoção da alimentação saudável. Os resultados deste estudo fornecem evidência nesse sentido. Alunos que almoçam no refeitório têm hábitos alimentares mais saudáveis, com uma maior adesão ao Padrão Alimentar Mediterrânico. Este resultado justifica a implementação no futuro de medidas que continuem a promover o aumento da adesão ao refeitório dos alunos do 2º, 3º ciclos e secundário.

4.2 OUTROS RESULTADOS IMPORTANTES

O projeto R23 produziu também informação importante sobre hábitos alimentares e estado nutricional dos alunos de 2º e 3º ciclos de Benavente. Cerca de 35.6% (n=278) dos alunos têm excesso de peso, destes 13.4% (n=105) são obesos. Mais de metade dos alunos (57.3%; n=449) tem uma adesão baixa/moderada ao Padrão Alimentar Mediterrânico. A medição do perímetro da cintura revelou que 10.9% (n=85) têm um risco aumentado de doença cardiovascular.

Estes dados traduzem uma situação preocupante nesta região e são uteis para fundamentar a necessidade de investir em futuros projetos nesta área da alimentação escolar.

4.3 IMPLICAÇÕES PARA FUTUROS PROJETOS

Os resultados deste estudo têm implicações práticas importantes para as futuras recomendações/orientações relacionadas com ementas e refeitórios escolares. É extremamente importante reconhecer que as refeições escolares não podem ser vistas somente como uma medida de ação social. Para garantir que a alimentação escolar contribui para hábitos alimentares mais saudáveis e para o bem-estar é necessária uma adesão ao refeitório mais elevada. E para tal é imprescindível trabalhar com a comunidade escolar no sentido de desenvolver um serviço de alimentação escolar mais alinhado com as suas necessidades e preocupações.

4.4 LIMITAÇÕES E MAIS VALIAS

Que saibamos este é o primeiro estudo multicomponente realizado em Portugal, baseado em princípios de participação colaborativa, também conhecida por cocriação, focado em aumentar a adesão dos alunos do 2º e 3º ciclos ao refeitório escolar e a satisfação com o almoço escolar, com uma metodologia quase-experimental.

A evidência científica produzida neste projeto permite também fundamentar a importância da intervenção de nutricionistas nas autarquias. Com um desenho de estudo robusto, um investimento publico baixo, conseguimos mobilizar toda a comunidade escolar para este problema da baixa adesão ao refeitório e transformar um serviço de refeições escolares mais apelativo para os alunos e pais.

As limitações já foram descritas nos artigos. No entanto, interessa salientar a necessidade deste tipo de projetos ter uma duração mais longa de forma, não só a capturar o efeito do aumento da adesão ao refeitório no IMC, WHTR e adesão à DM, mas também para produzir resultados consistentes no tempo.

5 REFERÊNCIAS BIBLIOGRÁFICAS

1. Hunter D, Giyose B, PoloGalante A, Tartanac F, Bundy D, Mitchell A, et al. Schools as a system to improve nutrition: a new statement for school-based food and nutrition interventions. United Nations System Standing Committee on Nutrition. 2017
2. Oostindjer M, Aschemann-Witzel J, Wang Q, Skuland SE, Egelandsdal B, Amdam GV, et al. Are school meals a viable and sustainable tool to improve the healthiness and sustainability of children's diet and food consumption? A cross-national comparative perspective. Critical Reviews in Food Science and Nutrition. 2017; 57(18):3942-58.
3. Hoijer K, Lindo C, Mustafa A, Nyberg M, Olsson V, Rothenberg E, et al. Health and Sustainability in Public Meals-An Explorative Review. International Journal of Environmental Research and Public Health. 2020; 17(2)
4. Assembleia da República. Lei n.º 34/2019. Diário da República, Série I; 98(2019-05-22): 2544 - 46. Define os critérios de seleção e aquisição de produtos alimentares, promovendo o consumo sustentável de produção local nas cantinas e refeitórios públicos.
5. Assembleia da República. Lei n.º 11/2017. Diário da República, Série I; 75(2017-04-17): 1974 - 74. Estabelece a obrigatoriedade de existência de opção vegetariana nas ementas das cantinas e refeitórios públicos.
6. Parlamento Europeu e do Conselho. Regulamento (CE) n.° 178/2002. Jornal Oficial nº L 031; 2002-02-01): 0001-24. Que determina os princípios e normas gerais da legislação alimentar, cria a Autoridade Europeia para a Segurança dos Alimentos e estabelece procedimentos em matéria de segurança dos géneros alimentícios.
7. Parlamento Europeu e do Conselho. Regulamento (CE) n.° 852/2004. Jornal Oficial nº L 139; 30-4-2004): 0001-23. Relativo à higiene dos géneros alimentícios.
8. Ministério da Educação - Gabinete da Secretária de Estado Adjunta e da Educação. Despacho n.º 8127/2021. Diário da República Série-II; 159(2021-08-17): 44 - 49. Estabelece as normas a ter em conta na elaboração das ementas e na venda de géneros alimentícios nos bufetes e nas máquinas de venda automática nos estabelecimentos de educação e de ensino da rede pública do Ministério da Educação.
9. Presidência do Conselho de Ministros. Resolução do Conselho de Ministros n.º 132/2021. Diário da República Série-I; 178(2021-09-13): 10-46. Aprova a Estratégia Nacional de Segurança Alimentar e Nutricional.
10. Finanças AI, Educação, Saúde, Economia, Agricultura, Florestas, Desenvolvimento Rural e Mar,. Despacho n.º 11418/2017. Diário da República Série-II; 249(2017-12-29): 29595-98. Estratégia Integrada para a Promoção da Alimentação Saudável.
11. Direção-Geral da Educação. Circular nº.: 3097/DGE/2018. Orientações sobre ementas e refeitórios escolares. 2018-08-08. Orientações sobre ementas e refeitórios escolares.
12. Graça P, Lima Matias R, Gregório MJ. A alimentação escolar em Portugal - uma visão estratégica. In: Ministério da Educação - Direção-Geral da Educação, editor.; 2021. Disponível em: https://www.dge.mec.pt/sites/default/files/Noticias_documentos/a_alimentacao_escolar_em_portugal_-_uma_visao_estrategica.pdf.
13. Madeira BMC. Adesão aos refeitórios escolares no 2º, 3º ciclos e ensino secundário. Instituto Superior de Ciências da Saúde Egas Moniz; 2014. Disponível em: https://comum.rcaap.pt/handle/10400.26/13938.

14. Moreira P, Ávila H, Correia MJ. Quantificação do desperdício alimentar em refeitórios escolares: impacto de uma campanha de sensibilização. Acta Portuguesa de Nutrição. 2021; 24:38-45.
15. da Silva B, Teixeira B, Ávila H, Afonso C. Avaliação do desperdício alimentar da refeição almoço em duas escolas públicas do distrito de Aveiro. Acta Portuguesa de Nutrição. 2020
16. Ferreira M, Martins ML, Rocha A. Food waste as an index of foodservice quality. British Food Journal. 2013
17. Lopes C, Torres D, Oliveira A, Severo M, Alarcão V, Guiomar S, et al. Inquérito Alimentar Nacional e de Atividade Física IAN-AF 2015-2016: relatório de resultados. 2017
18. Fox M, Gearan E, Cabili C, Dotter D, Niland K, Washburn L, et al. Student participation, satisfaction, plate waste, and dietary intakes. School Nutrition and Meal Cost Study. 2019; 4
19. Cohen JFW, Hecht AA, McLoughlin GM, Turner L, Schwartz MB. Universal School Meals and Associations with Student Participation, Attendance, Academic Performance, Diet Quality, Food Security, and Body Mass Index: A Systematic Review. Nutrients. 2021; 13(3):911.
20. Cohen JFW, Hecht AA, Hager ER, Turner L, Burkholder K, Schwartz MB. Strategies to Improve School Meal Consumption: A Systematic Review. Nutrients. 2021; 13(10):3520.
21. Carvalho ÁC, Matos C, Minderico C, Almeida CTd, Abrantes E, Mota EA, et al. Referencial de Educação para a Saúde. 2017
22. Payán DD, Sloane DC, Illum J, Farris T, Lewis LB. Perceived barriers and facilitators to healthy eating and school lunch meals among adolescents: A qualitative study. American journal of health behavior. 2017; 41(5):661-69.
23. Meiselman HL, Johnson JL, Reeve W, Crouch JE. Demonstrations of the influence of the eating environment on food acceptance. Appetite. 2000; 35(3):231-7.
24. Fox MK, Gearan E, Cabili C, Dotter D, Niland K, Washburn L, et al. School Nutrition and Meal Cost Study final report volume 4: Student participation, satisfaction, plate waste, and dietary intakes. Mathematica Policy Research; 2019.
25. Bailey-Davis L, Virus A, McCoy TA, Wojtanowski A, Vander Veur SS, Foster GD. Middle School Student and Parent Perceptions of Government-Sponsored Free School Breakfast and Consumption: A Qualitative Inquiry in an Urban Setting. Journal of the Academy of Nutrition and Dietetics. 2013; 113(2):251-57.
26. Mirtcheva DM, Powell LM. Participation in the National School Lunch Program: Importance of School-Level and Neighborhood Contextual Factors. Journal of School Health. 2009; 79(10):485-94.
27. Van Cauwenberghe E, Maes L, Spittaels H, van Lenthe FJ, Brug J, Oppert J-M, et al. Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and 'grey' literature. Br J Nutr. 2010; 103(6):781-97.
28. Tay BSJ, Cox DN, Brinkworth GD, Davis A, Edney SM, Gwilt I, et al. Co-Design Practices in Diet and Nutrition Research: An Integrative Review. Nutrients. 2021; 13(10):3593.
29. Leask CF, Sandlund M, Skelton DA, Altenburg TM, Cardon G, Chinapaw MJM, et al. Framework, principles and recommendations for utilising participatory methodologies in

the co-creation and evaluation of public health interventions. Res Involv Engagem. 2019; 5:2.
30. Models of co-creation. Service Design Geographies Proceedings of the ServDes 2016 Conference; 2016. Linköping University Electronic Press.