

# Effects of a practice-focused nutrition intervention in Hungarian adolescents

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## Abstract

**Introduction.** This work evaluated the impact of a nutrition intervention in school children of 6th and 7th grade and assessed whether changes persisted after the summer break.

**Materials and methods.** Eight classes of Hungarian adolescents (45% boys; 12.6 ± 0.1 years) were randomized into intervention (n = 117) and control (n = 112) groups. The 9-month long intervention included: 1) weekly classroom-based education with strong focus on practical elements such as tasting and meal preparation; 2) five sessions of after-school cooking classes (open to children, parents and grandparents); and 3) online education materials. Anthropometric parameters (weight, height, waist circumference and body fat), aerobic fitness (Cooper test, 20-meter shuttle run test), nutrition knowledge and behaviors (questionnaires) were measured three times at baseline, post-intervention and after the summer holiday.

**Results.** Slight improvement in dietary knowledge and habits from baseline to post-intervention which did not persist after summer. Aerobic fitness increased in the intervention group, while did not change among controls. Anthropometric parameters remained unchanged in the intervention group, but waist circumference increased in controls, particularly in summer.

**Conclusions.** Findings suggest a positive impact of this intervention. Measures to mitigate unhealthy changes during the summer break are needed.

## Key words

- school-based
- nutrition
- education
- obesity
- adolescents

## INTRODUCTION

Publications on malnutrition in the form of obesity and nutrient deficiency presented alarming figures both for European adults [1, 2] and children [3, 4]. Similarly to other parts of Europe, Hungary has a high rate of child obesity [5]. Compliance with dietary recommendations is also poor [6]; and low level of physical activity and aerobic fitness is highly presented, particularly in older age groups (NETFIT).

Because of their current and lifetime impact, these risk factors need to be addressed via a range of approaches from individual to environmental interventions [7-9]. Among environmental settings, school has a unique role and huge potential to reach out a large number of children and to promote healthy behaviors [10]. In Hungary, a number of regulations have been introduced in the last ten years aiming to create an enabling school environment [11]. Three mandatory regulations apply nationwide: the introduction of daily physical education (PE) classes in the academic year of 2012/2013 in a step-up implementation system, the national standards for public catering which came into force in 2015 and the prohibition of selling of those foods and drinks in

schools that are subject to the Public Health Product Tax. Besides, within the framework of the EU School Fruit, Vegetables and Milk Scheme students from 2157 primary schools (90% of all schools) get fresh fruit and vegetable daily [12]. Finally, since the academic year of 2016/2017, the education on biology and health including lessons on healthy diet and nutrition was also introduced from grade 7th on a stepwise manner.

Adolescence, defined as the transitional phase between childhood and adulthood, is one of the critical intervention periods. This is the time when young people begin to make their own choices and decisions related to their diet and health, as well as to establish lifestyle habits that will carry over into adulthood [9]. Besides, the prevalence of overweight and obesity as well as lifestyle-related risk factors are high at this age [6].

Recent evidence shows that school-based education interventions have the potential to improve children's weight status, knowledge and lifestyles if running for a sufficient duration and targeting also the family members [13]. However, only limited information is available to understand whether these programs can increase cardiovascular fitness and whether the improvements last

after the summer holiday. This study therefore aimed to develop a whole-year school-based nutrition intervention for adolescents with an emphasis on practical education, active participation and family involvement, and to evaluate its effects on participants' dietary knowledge and behavior, as well as on weight status and aerobic fitness using an intervention-control study design. Knowing that inadequate intake of nutrients and calories can impair exercise performance [14]; in the present work it was hypothesized that improving diet quality in adolescents would possibly increase their aerobic capacity. The secondary objective was to study whether these changes would persist after the summer holiday.

## MATERIALS AND METHODS

### *Study population and recruitment strategies*

Budaors is a town in Pest county with a total population of 28 394 inhabitants. It is one of the most developed towns in Hungary, with four state-owned primary schools. For the purpose of this study, two primary schools were enrolled. Participating schools had similar socio-demographic characteristics. One had a total of 808 students from grade 1st to 8th; with an average classroom size of 30 students. The other school was smaller with a total number of 463 students, and with an average classroom size of 26 pupils.

From the two enrolled schools, a total of eight classes were selected from grade 6th and 7th (two 6th and two 7th grade classes from each school). Classes in each grade were then randomized into intervention or control groups.

Recruitment of the study population took place in September 2015 during the registration period. Parents were contacted and informed about the purpose and processes of the study during the first parents' meeting of the academic year. All parents agreed to participate in the study and were contacted for completing the baseline parental questionnaire. All study participants gave their informed consent for inclusion before participating in the study. The work was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Scientific and Research Ethics Committee of the Medical Research Council (8776-1/2016/EKU).

### *Description of the intervention*

The intervention included three main components: 1. weekly classroom-based education (25 to 45 minutes long); 2. five sessions of after-school cooking classes (open to the entire family); and 3. online education materials distributed via e-mails and social media. Children in grades 6 and 7 within the intervention classes received the combination of all components, whereas children in the control classes continued their usual curriculum.

The weekly classroom-based education developed in this study included both theoretical and practical parts and were led by the same trained dietician in each intervention class. A total of 27 interactive sessions were delivered over the period of 9 months. Sessions started with the theoretical part followed by a tasting or meal preparation activity. During the first academic semester tasted foods were prepared by the dietician in advance.

Meanwhile, in the second semester, children prepared the foods in the schools' small kitchen unit as part of the session with the help of the dietician. Topics covered within the education sessions included the principles of healthy nutrition, relation between nutrition and health, the role of different nutrients, importance of different meals (i.e. breakfast, lunch, dinner and snacks), healthy snacking, role and recommended amount of different food groups, labelling, and healthy party tips. Games and tasting were incorporated to reinforce main messages of each session. Detailed description of each session is presented as a supplementary file.

After-school cooking classes were offered five times in the second semester and were attended by children, parents and grandparents. They aimed on one hand to educate caregivers, but also to increase the involvement of children in meal preparation and cooking. Similarly to classroom-based activities, these sessions had both theoretical and practical parts, but here more emphasis was put on practice. Activities were organized in the schools' small kitchen unit and typically lasted 1 or 2 hours. Sessions addressed the following questions and topics: "How to make kids eat fruits and vegetables? (2 sessions)", "How to reduce dietary risk factors?", "The importance of breakfast" and "How to reduce added sugar?" (see *Supplementary Material available online*).

Recipes posted on Facebook or sent via e-mail completed the intervention and strengthened its family-involvement component.

### *Data collection procedures*

Information on students' age, gender, dietary knowledge and behavior were collected by a 29-item questionnaire. Children completed the questionnaire with the assistance of a trained field worker in their classroom. In the present paper we analyzed the following parts of the questionnaire: 1) age and gender; 2) nutrition knowledge section (6 questions) which covered the areas of healthy nutrition in general, recommended amount of fruits and vegetables, recommended fluid intake, energy drinks and sugary drinks; and 3) dietary behaviour section (10 questions) which assessed the frequency of breakfast skipping, number of meals, frequency of eating fast food, daily fluid intake, as well as the frequency of dairy products, fruits, vegetables, sweets, energy drinks and sugary drinks consumption. For the purpose of the current paper, nutrition knowledge and dietary behaviour questions were separately analyzed. Each correct answer for the nutrition knowledge questions was allocated a score of 1 point; all others received 0. The total knowledge score ranged between 0 and 6 points with higher scores indicating a better nutrition knowledge. For the dietary behaviour questions, favorable options were scored as 1 point and others got 0. Thus, the total behavior score ranged from 0 to 10 points with a higher score reflecting healthier dietary behaviour.

Anthropometric measurements of children (weight, height, waist circumference, fat mass) were obtained using standard protocols and equipments by a trained dietician with the support of the physical education teachers. Children's verbal permission was requested before taking the measurements. Weight was measured

to the nearest 0.1 kg in light indoor clothing with bare feet, using portable digital calibrated scales (OMRON BF 511) and height was measured standing upright, without shoes, to the nearest 0.1 cm using a 2M wall-mounted stadiometer roll-up height measurer. Fat mass was estimated by using the same equipments as for the weight measurements (OMRON BF 511). These scales use 8-sensor single-frequency bioelectrical impedance analysis technology and offering hand-to-foot measurements to improve accuracy [15]. A non-stretchable measuring tape (Seca 201) was used to measure waist circumference of children above the iliac crest to the nearest 0.1 cm, with the subject standing and after normal expiration [16]. Anthropometric measurements were taken only once for each child.

Physical fitness assessments followed the Hungarian National Student Fitness Test (NETFIT) protocol [17], which now serves as a compulsory fitness assessment for all Hungarian schools. NETFIT test has four parts: 1) body composition and weight status incl. weight, height and body composition measurements; 2) aerobic fitness incl. 20-meter shuttle run test [18]; 3) muscle strength and endurance incl. paced curl-up, trunk lift, paced push-up, handgrip strength and standing long jump tests; and 4) flexibility incl. back-saver sit-and-reach test. Evaluation is based on health-related, criterion-referenced youth fitness standards. In the present study, the NETFIT protocol was completed with a Cooper test which was designed to measure aerobic fitness [19]. The results of this 12 minutes long running test can be correlated with  $VO_2$  max values. The longer distance is covered in 12 minutes the higher is the estimated  $VO_2$  max value, and therefore higher is the estimated aerobic capacity. So, both in Cooper and in 20 meters shuttle run tests higher values indicating a better fitness status.

### Data analysis

All data was processed anonymously. EpiData Entry 3.1 software was used for data entry, which included built-in range (e.g. outliers, out of range values) and consistency checks for validation. In order to get the exact age of each child, the birth date was subtracted from the measurement date then variables with age in years were created. Body mass index (BMI) ( $kg/m^2$ ) was calculated by dividing the weight (kg) over the height squared ( $m^2$ ). Children were classified as underweight, normal weight, overweight or obese based on the age- and gender-specific IOTF cut-offs [20]. Descriptive statistics were performed and presented as means and standard error (SE) for continuous variables and as frequencies and proportions for categorical variables. At baseline, between-group differences (i.e. intervention versus control groups) in age, anthropometric characteristics, knowledge and behaviour scores and fitness status of participants were assessed using Student's t-test. For categorical variables chi-square tests were applied. Paired t-tests were used to compare independently the differences between baseline, post-intervention and follow up within each of the intervention and control groups (within-group differences). In addition, between-group differences (intervention versus control groups) in mean changes were evaluated using Student's

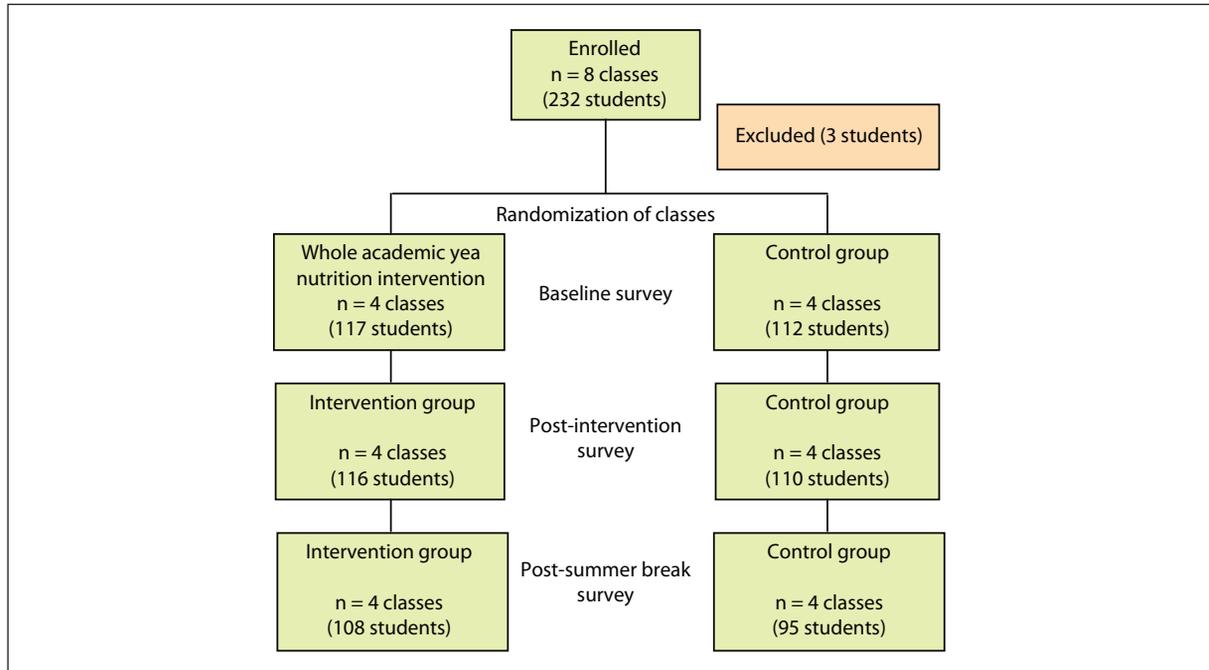
t-tests. As gender distribution was significantly different at baseline between the intervention and control groups, generalized linear regression analyses were conducted to test the effect of gender on mean changes in anthropometric parameters, nutrition knowledge score, dietary habits score and in aerobic fitness status. We also tested whether our conclusions were biased by an interaction between gender and group status (i.e. intervention or control), but no interaction was identified. A p-value of  $< 0.05$  was considered statistically significant.

### RESULTS

Data were collected at baseline from 232 children, 226 children completed the post-intervention tests (97.4%) and 203 participated in the follow-up evaluation (87.5%) (Figure 1). At the end, three children were excluded from the analysis due to the large number of missing data, so the current analysis is based on the data of 229 children.

At baseline, mean age of all enrolled children was  $12.6 \pm 0.1$  years and gender distribution was slightly unequal (44.5% boys and 55.5% girls). Significant differences were observed between the intervention and control group at baseline ( $p = 0.003$ ) in gender distribution (i.e. lower proportion of boys in the intervention group), BMI (i.e. slightly higher mean BMI in the intervention group), number of children with obesity (i.e. higher proportion in the intervention group) and aerobic fitness status (i.e. lower aerobic fitness in the intervention group). However, age, waist circumference, fat mass, nutrition knowledge score and dietary habits score did not differ significantly between the two groups (Table 1).

Table 2 presents between-group differences (intervention versus control) with respect to mean change from baseline to post-intervention and from baseline to follow-up in anthropometric parameters, nutrition knowledge and dietary habits scores as well as in aerobic fitness tests. No significant changes in BMI, waist circumference or fat mass were noted in the intervention group, while waist circumference increased in the control group from baseline to follow-up ( $67.5 \pm 1.0$  cm versus  $72.8 \pm 1.0$  cm,  $p < 0.001$ ). The number of children with obesity decreased from 8 to 7 in the intervention group, while increased from 2 to 7 among the control children from baseline to post-intervention. By the end of the summer break, there were 6 children with obesity in both groups. The nutrition knowledge score slightly decreased in the control group, but an increase was observed in the intervention group from baseline to post-intervention ( $3.79 \pm 0.1$  point versus  $4.14 \pm 0.1$  point,  $p = 0.04$ ). However, the score decreased back to baseline level by the time of the follow-up. Similarly, there was a small increase in the dietary habits score in the intervention group from baseline to post-intervention ( $4.35 \pm 0.2$  point versus  $4.5 \pm 0.2$ ;  $p = 0.02$ ). However, the favorable change did not persist after the summer holiday. In contrast, in the control group the score decreased from baseline to post-intervention and remained low by the time of the follow-up. Aerobic fitness improved significantly from baseline to post-intervention in the intervention group (Cooper test:  $2020.3 \pm 39.9$  m versus  $2256.3 \pm 39$  m,  $p < 0.001$  and 20-me-

**Figure 1**

Total number of classes and participants in the intervention and control groups at the time of the three assessments (i.e. at baseline, post-intervention and after the summer break).

**Table 1**

Baseline characteristics of intervention and control children participated in the school-based nutrition intervention in Budaors (n = 229)

Dependent variables	Intervention group (n = 117)	Control group (n = 112)	p-value
Boys-girls, n (%)	41-76 (35-65%)	61-51 (54.5-45.5%)	0.003
Age (years)	12.5 ± 0.1	12.6 ± 0.1	0.572
Weight (kg)	51.7 ± 1.2	49.6 ± 1.1	0.179
Height (cm)	158.9 ± 0.8	159.7 ± 0.7	0.386
BMI (kg/m <sup>2</sup> )	20.4 ± 0.4*	19.3 ± 0.3**	0.037
Weight status – overweight, n (%)	21 (18.4%)*	22 (20.6%)**	0.613
Weight status – obese, n (%)	8 (7%)*	2 (1.9%)**	0.073
Waist circumference (cm)	68.2 ± 0.9	67.5 ± 1.0	0.645
Fat mass (%)	20.4 ± 0.9	18.3 ± 0.7	0.063
Nutrition knowledge score <sup>#</sup>	3.8 ± 0.1	3.9 ± 0.1	0.479
Dietary habits score <sup>§</sup>	4.6 ± 0.2	4.2 ± 0.2	0.140
Cooper test (m)	2020.3 ± 39.9	2134.1 ± 41.2	0.048
20-m shuttle run test	37.1 ± 1.5	41.7 ± 1.7	0.046

Unless otherwise noted, numbers are means ± standard errors (SE). Clustered independent t-tests were used to compare continuous variables and chi-square tests were applied for categorical variables. BMI, body mass index. \*n = 114. \*\*n = 105. <sup>#</sup>Total score ranged from 0 to 6. <sup>§</sup>Total score ranged from 0 to 10.

ter shuttle run test: 37.1 ± 1.5 vs 43.4 ± 1.6,  $p = 0.004$ ). There was inconsistency between the Cooper and the 20-meter shuttle run test results from post-intervention to follow up as mean Cooper test result decreased but 20-meter shuttle run test result increased (Cooper test: 2173.6 ± 41.9 m, 20-meter shuttle run test: 45.9 ± 1.9). Significant changes were not observed in aerobic fitness in the control group.

To study whether these changes were the results of

the unbalanced gender distribution between the two groups or can be considered as intervention effects we made a gender adjusted regression analysis (Table 3). Changes in nutrition knowledge score, dietary habits score and in Cooper test from baseline to post-intervention remained significant after adjusted for gender. Besides, after adjusting for gender, changes in waist circumference and 20-m shuttle run test achieved statistical significance from baseline to follow-up.

**Table 2**

Between-group differences (intervention vs control) in mean change of anthropometric parameters, nutrition knowledge score, dietary habits score and aerobic fitness status of study participants (n = 229)

Dependent variables	From baseline to post-intervention		p-value	From baseline to follow-up		p-value
	Intervention	Control		Intervention	Control	
Weight (kg)	2.7 ± 0.3	3.6 ± 0.3	0.039	4.6 ± 0.4	5.4 ± 0.4	0.166
Height (cm)	2.6 ± 0.2	2.8 ± 0.2	0.487	4.7 ± 0.3	5.5 ± 0.4	0.097
BMI (kg/m <sup>2</sup> )	0.4 ± 0.1	0.7 ± 0.1	0.083	0.6 ± 0.1	0.7 ± 0.2	0.560
Waist circumference (cm)	1.1 ± 0.5	2.2 ± 0.4	0.084	1.8 ± 0.5	6.5 ± 0.7	0.000
Fat mass (%)	0.9 ± 0.5	0.4 ± 0.4	0.385	0.4 ± 0.5	-0.03 ± 0.6	0.556
Nutrition knowledge score	0.3 ± 0.2	-0.3 ± 0.2	0.004	-0.1 ± 0.2	-0.5 ± 0.2	0.136
Dietary habits score	0.2 ± 0.2	-0.6 ± 0.2	0.021	-0.5 ± 0.2	-0.8 ± 0.2	0.271
Cooper test (m)	236.2 ± 28.3	22.8 ± 31.7	0.000	138.8 ± 39	136.6 ± 48.3	0.972
20-m shuttle run test	5.5 ± 0.9	3.9 ± 1.1	0.270	8.4 ± 1.3	2.7 ± 1.5	0.005

Numbers are means ± standard errors (SE). BMI, body mass index.

**Table 3**

Results of gender adjusted regression analysis based on general lineal model for two kinds of time interval: from baseline to post-intervention and from baseline to follow-up. Intervention coefficient shows difference of change regarding the intervention group compare to the control group

Dependent variables	From baseline to post-intervention			From baseline to follow-up		
	Intervention coefficient	SE	p-value	Intervention coefficient	SE	p-value
Weight (kg)	-0.694	0.418	0.097	-0.325	0.520	0.532
Height (cm)	-0.016	0.280	0.954	-0.218	0.397	0.582
BMI (kg/m <sup>2</sup> )	-0.271	0.164	0.099	-0.103	0.204	0.615
Waist circumference (cm)	-1.012	0.668	0.130	-4.541	0.811	0.000
Fat mass (%)	0.207	0.600	0.730	-0.204	0.741	0.783
Nutrition knowledge score	0.723	0.237	0.002	0.487	0.272	0.085
Dietary habits score	0.713	0.318	0.025	0.453	0.313	0.148
Cooper test (m)	215.07	43.17	0.000	-3.832	62.490	0.951
20-m shuttle run test	1.858	1.490	0.212	5.679	2.035	0.005

## DISCUSSION

This work evaluated the impact of a whole school year nutrition intervention on nutrition knowledge, dietary behavior as well as on nutritional and fitness status in Hungarian adolescents. Findings suggest small beneficial changes in dietary knowledge and habits from baseline to post-intervention, which could not be sustained by the end of the summer holiday. In contrast, significant improvements were noted in aerobic fitness in the intervention group which could be detected even at the follow-up. Finally, an increase was found in waist circumference and number of children with obesity in the control group while these parameters did not change among the intervention group participants.

Increasing knowledge by nutrition education is thought to be an effective measure for establishing healthy dietary habits throughout the lifespan [21]. At baseline, the average nutrition knowledge score both in the intervention and control groups was around 3.8 out of 6. Given that the six questions were simple and basic;

this is relatively low. Nutrition knowledge of adolescents is often inadequate [22, 23] which is an issue as without sufficient knowledge of this subject they cannot understand the impact of their choices on overall health. This poor knowledge was reflected in the low dietary habit scores. The association between dietary knowledge and behavior is well known and provides the theoretical basis for nutrition education interventions [21]. In the presented work we were able to slightly increase knowledge and improve dietary habits in the intervention group by the end of the 9-month program, while we detected a mild decrease both in knowledge and behavior among the control group for this period. However, these beneficial effects could not be maintained during the summer holiday. These intervention effects on dietary knowledge and habits are consistent with the results of previous nutrition education interventions implemented in the school setting among adolescents [24-27], however only two of these studies included a follow up [26, 27]; and none of the works included explicit post-summer holi-

day assessments. Public health professionals all over the world are continuously working on improving children's diet. Despite the field's best efforts, not much progress has been made on this area [2]. One reason for this failure may be that health promotion and disease prevention programs, like ours, are mainly delivered during the academic period and much less activities are happening during the summer break. To move forward, public health professionals should develop strategies to mitigate unhealthy changes during summer.

Schools are the most important locations for implementing nutrition related educational programs among children and adolescents [28]. However, the evidence on the effective elements of these interventions on dietary habits is inconsistent [29]. Whole academic year duration, strong focus on practical education and involvement of parents and grandparents are those elements that we consider as the most effective ingredients of this program. Other studies also reinforced the importance of building partnerships with parents to complement school-based education programs [30]. In the current work we offered after school cooking lessons for the entire family including children, parents and grandparents. Although participation rate was low, those who attended the extra classes found it very useful. Online education materials and recipes have also targeted the parents. Beside family involvement, practical hands-on experience seems to be also essential for realizing positive behavioral changes in youth [28, 31]. Strategies suggested by adolescents to support healthy diet are, among others, greater cooking involvement, adolescent-specific recipe books and greater parental and peers support [29]. Consequently, the program described here put high emphasis on adding practical elements to every classes. An experimental approach was chosen to provide opportunities to learn about and become familiar with a variety of minimal processed foods. Tasting new foods or ingredients, developing skills in food preparation and making it an enjoyable activity were also considered as key strategies in our study. Few previous interventions have included cooking classes to improve diets in adolescents. For example, in a recent review, only two interventions involved both nutrition education and cooking classes, while only other two included tasting sessions parallel with cooking [32]. Cooking should be re-integrated into the academic curriculum as a compulsory component. Particularly, as lack of cooking skills is one of the most commonly mentioned barriers by adolescents to preparing food at home [33], and consequently they turn more often to less healthy options such as convenience foods or eating out [34].

The association between athletic performance and nutrition is well-known from the literature [35]. Although one's fitness level cannot be increased simply by eating better, unhealthy nutrition can be a limiting factor for performance and recovery [35]. Therefore, in this study we hypothesized that if we improve adolescents' dietary habits it may influence their aerobic capacity. So far, only few publications focused on the relationship between diet and physical fitness in children. Chung and colleagues emphasized the benefits of balanced diet on fitness levels in 6-12 years old children [36]. However, authors noted

that beyond diet there are several other factors that affect physical fitness level. As for interventions, according to our knowledge, no other studies assessed the effects of a program with only nutrition-focused activities on physical fitness in children. Da Silva *et al.* performed a study in Brazilian school children and found a marked improvement in fitness, however the intervention included structured physical activities together with the nutritional education element [37]. In this study, the results showed significant improvements in aerobic fitness tests in the intervention group both from baseline to post-intervention and from baseline to follow-up, while no significant changes were noted in the control group. Due to the lack of data in the literature, it was not possible to compare these findings with other results.

On the other hand, the average of BMI, waist circumference and fat mass did not change in the intervention group; whereas in the control group there was a mean increment of 6.5 cm in waist circumference ( $p < 0.001$ ) at the time of the follow-up. Other school-based nutrition education studies conducted in adolescents have shown mixed results with respect to anthropometric outcomes [24, 25]. Differences in results between studies can be attributed to a number of factors, such as differences in intervention elements or variations in participants' baseline characteristics. The increase in mean waist circumference in the control group is remarkable and deserves some thoughts. Adolescence can be considered a critical time for the onset of obesity [38]. Waist circumference has been considered as an important data for visceral fat accumulation, however assessment should be performed in adolescents according to their pubertal staging, since changes are strongly influenced by sexual maturation [39]. In our study, we did not collect data on pubertal stage thus this analysis could not be performed. But we assumed that sexual maturation could explain this sudden increase.

Our study has some limitations that warrant considerations. The gender difference at baseline between the intervention and control groups could lead to a selection bias. Sex differences in body composition (i.e. fat and muscle mass) as well as in aerobic capacity is well known from the literature [40, 41]. These differences are more remarkable during adolescents than in children due to the impact of sex specific hormones. Given that in our study the intervention group had higher mean BMI and lower aerobic fitness at baseline, the beneficial effects of the intervention on these parameters can be considered as more significant. Second, as only limited number of completed parental questionnaire were sent back to the research group we were not able to properly analyze and present these results. Parental nutrition knowledge and dietary habits have strong impact on the diet of their offspring [42, 43]. Therefore, it would have been better if we would be able to capture beneficial changes among the participants' parents. Third, dietary habits, one of the most important outcome of our work, were self-reported and therefore are subject to recall bias. However, currently questionnaire based surveys are still the most frequently used instruments to evaluate dietary habits [44], so we were not in a position to deliver objectively measured data in this regard. Finally, the

intervention in its current form is quite labour and resource intense which diminishes its potential to transfer the work for a different target group in other context. However, some elements needed less resources such as the distribution of the online educational materials; while others, like the developed education material, could be built into the regular school curriculum after slight modification to reduce the costs. The curriculum of the current nutrition intervention can also complement the national implementation of the EU School Fruit, Vegetables and Milk Scheme in which funding is available for educational measures [12]. Despite these limitations, this study certainly provides tools to include in future works in this area.

## CONCLUSIONS

This work evaluated the impact of a whole school year nutrition intervention in Hungarian adolescents. Small beneficial changes in dietary knowledge and habits from baseline to post-intervention were observed which did not persist by the end of the summer holiday. In addition, remarkable increase was found in waist circumference and number of children with obesity in the control group during summer. These findings have important implications for practice as weight gain and unhealthy lifestyle changes during summer can undermine the beneficial effects of school-based interventions. Moving for-

ward, experts need to identify ways to avoid unhealthy shifts in diet, physical activity and sleep during the summer break. In contrast, for the first time, significant improvements were detected in aerobic fitness of children after a nutrition-focused intervention. Future research may continue to study and validate this possible impact and to understand the underlying mechanisms.

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## Authors' contribution statement

HT developed the protocol under the supervision of EM and organized and carried out the field work. HT also drafted the manuscript. EM supervised the data collection and coordinated the field work. VAK critically revised the manuscript. All authors had final approval of the submitted version.

## Conflict of interest statement

The authors declare no conflict of interest.

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