Evaluation of the effects of an interdisciplinary lifestyle and health program for adolescents and its benefits for maintaining health.

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Research

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Abstract

Background

Obesity numbers have doubled worldwide since 1980, leading to individual life-quality threatening issues and a socioeconomic challenge. A number of school programs have been initiated to prevent the epidemic-like spreading of obesity.

Methods

109 adolescents (42 females and 67 males aged 15.0 ± 0.7 years) were included into this six-month interdisciplinary school-based study. The aim was to assess various implementation outcomes based on the effect of health education, including the promotion of healthy eating patterns and a limitation of sugar-containing beverage consumption via the feedback of analysed anthropometric data, biomedical parameters, physical fitness tests and an eating and physical activity behaviour questionnaire.

Results

Overall, the results demonstrated a positive effect on body fat content and physical activity. In addition, a trend towards a benefit on parameters of muscle and fat metabolism was detected.

Conclusions

An interdisciplinary life-style program integrated into the school curriculum is suited to have a positive impact on health outcomes. By enhancing the awareness for healthy nutrition and the importance of physical activity, self-empowerment was increased, resulting in an improvement of health-associated parameters.

Background

Due to epidemic-like spreading, childhood obesity has become not only an individual life-quality threatening issue, but also a socioeconomic challenge (1–4). In adolescents at the age of 19 years, the cut-off values for overweight are defined as a body mass index (BMI) ≥ 25.0 kg/m² and obesity as an excess amount of body fat accompanied with a BMI ≥ 30.0 kg/m² in both sexes, which is equivalent to adults (5, 6). In contrast, the cut-offs for pre-school and school-aged children are age- and sex-related (7, 8). According to the fact sheet on overweight and obesity of the WHO (9), the incidence of obesity has worldwide more than doubled since 1980. A systematic review of Ng et al.(10) revealed that in 2013, the prevalence of overweight and obese children and adolescents in developed countries had increased substantially to 23.8% (22.9–24.7) in boys and 22.6% (21.7–23.6) in girls and that an increase can also be observed in developing countries.

Obesity is associated with comorbidities such as metabolic syndrome (11) diabetes mellitus (12), cardiovascular diseases (13, 14), musculoskeletal disorders and cancer (15). Longitudinal studies have shown that prenatal and postnatal factors can already be decisive to predict whether a child becomes obese (16–18). Therefore, information on a balanced diet and physical activity is important and prevention programs should start as early as possible. As we face large socioeconomic problems caused by an unhealthy lifestyle, any age class should be considered for prevention and if necessary for intervention.

To prevent obesity, different programs for pre-school children (19–21), primary school children (22, 20) and adolescents (23, 22) have been initiated. They differ in study design and the way of intervention. The IDEFICS-study was a comprehensive study investigating the effect of dietary- and lifestyle-induced health effects in children and infants in several different countries (24). The participants of this study were at the age of 2 to 9.9 years and the recruitment took place at pre-schools and primary schools. The key messages for intervention were focused on the reduction of soft drinks consumption, the daily intake of more fruits and vegetables, less media-time and more daily physical activity, increased family time and an adequate sleep duration.

To increase the outcome and effectiveness of such interventions in terms of public health decision making regarding health policies, programmes and practices, a framework for the design, execution and interpretation of health-related research has been initiated. This framework, summarised under the term *implementation research*, provides a number of key principles and implementation outcome variables for the design, execution and analysis of health related research (25).

The present study aimed to assess the feasibility of studying the implementation outcomes of an interdisciplinary school health project with regards to healthy nutrition and physical activity of adolescents aged 14 to 17 years. The aims were twofold, first to define the potential and adoption of this implementation project in schools and second to assess the acceptability, appropriateness and coverage of the planned intervention via the measurement of anthropometric data, biomedical parameters (26) and physical fitness parameters (health parameters). Moreover, a psychologically approved questionnaire about food preferences, physical activity and other individual factors was included. As intervention tool, hands on workshops increasing the awareness for nutrition and beverages and associated health parameters were used.

Methods

The study design meets the Helsinki Declaration (World Medical 2013) and was approved by the local ethics committee of the county of Salzburg, Austria. The participants of the study were informed collectively about the project and the planned measurements. In addition, they had the possibility for personal interviews, if there were any additional questions. Only students who provided their informed consent (by signing the information sheets themselves and by a parent or legal guardian) were included

in the study. All participants could stop the participation in this study at any given moment without the need to provide a reason. **The different analyses were performed at T0 (start of the study), T1 (1 month) and T2 (6 months). Initially, it was thought that certain parameters might change after weeks, but this was not the case. Therefore, time point T1** was not included in the analysis presented here, since the time frame of 1 month was too short to determine measurable effects of the dietary- and lifestyle-program. **The students were divided in a group obtaining health-related information (intervention-group: N=56) and a control-group (N=51).** Data were collected in a pseudo-anonymous manner. The students obtained a code and only the paediatrician knew the key between the codes and the respective students. In case of abnormal laboratory values, the student and his/her parents were informed and invited to an additional medical assessment by the paediatrician.

At the end of the school year, the head of the school and the teachers involved (natural sciences and sports) were asked for permission to perform the study in the following school year. At the beginning of the next school year, an informative meeting was organized for students and parents and they were asked to sign the informed consent form for the study. Based on the number of valid informed consent forms, the school visits of the teams of the different disciplines were planned in close cooperation with the teachers and administrators of the school. Venipuncture and anthropometric measurements were always performed during the first lesson and the students were instructed to fasten, i.e. not to eat or drink anything except water, ten hours before drawing the blood samples. To ensure protocol adherence, students were asked if they were able to follow the instructions before venipuncture. The time frame to draw blood and measure the values from 25 to 30 participants was calculated with approximately 30 to 40 min and a healthy breakfast was served right afterwards for all participants. The physical fitness tests were conducted by sports scientists trained for the Physical Fitness Test battery (PFTB) within the same week (27). Encoded questionnaires were handed out within the same week and were filled out by the students during one of their biology courses. The participants were randomized into a control group and an intervention group. The intervention group had workshops on nutrition, beverages and associated health parameters including anthropometric data, biomedical parameters, physical fitness parameters as well as eating behaviour directly after measuring baseline levels (T0) and the control group attended this workshop after the third measurement (T2). The workshop included theoretical information on various

types of food and its components, a hands-on workshop to estimate and determine fat, sugar and protein content of specific foods and beverages and a direct link to the analysis of certain health parameters, e.g. glucose. Moreover, a crossword puzzle and a quiz were included to test the acquired knowledge. The puzzle and the quiz were only performed to manifest the acquired knowledge; however, the analysis was not included in this study.

The different measurement tools were used at three time points. To exclude changes due to external influences, the participants were randomly assigned to an intervention or control group matched for age and gender.

Anthropometric data

Anthropometric measurements for evaluating body mass index (BMI) and waist-to-hip ratio (WHR) were performed with a medically approved stadiometer (Seca, Seca Austria, Wien, Austria) and reference tape and a segmental body composition analyser (Tanita BC-418, **Tanita Corporation of America, Inc., IL; USA) usually used in clinical research. Calculation of the standard deviation score for BMI (BMI- SDS) was performed via the formula:** Z-Score = $((BMI/M)^{L} - 1) / (L * S)$, whereby the values L (the power transformation for normalizing the BMI distribution at each sex/age), M (median) and S (coefficient of variation of BMI) are parameters from the Cole`s LMS method and are available on the CDC website. Z-scores (or standard deviation (SD) scores) are widely used in anthropometry to quantify a measurement's distance from the mean (28).

Biomedical data

The biomedical data were obtained as described previously (26). In brief, samples for biomedical analyses were withdrawn using the BD vacutainer® Push Button Blood collection set in combination with tubes for serum, Ethylendiamintetraacetat- and Li-Heparin-plasma (BD Becton Dickinson Austria GmbH, Vienna, Austria). The samples were transported and stored according to pre-analytical guidelines and good laboratory practise. A total of 50 laboratory parameters were measured. Care was taken to comply with good practice in pre-analytics, analytics and post-analytics. Laboratory parameters were analysed as previously reported (26).

Physical fitness test battery

Physical fitness was assessed by a standardized age- and percentile-matched physical fitness test battery (PFTB) (27). The test includes seven exercises for determining motor skills, strength, endurance and coordination. A detailed test description can be found in Table 1.

Table 1: Physical fitness test battery description.

	EXCERCISE	EVALUATION
MOTOR SKILLS	20-meter run (20MR)	Amount of time needed in seconds (2 runs are performed, faster run counts)
STRENGHT	Pull-ups (PU)	Number of pull-ups in 15 seconds
	Standing long jump (SLJ)	Distance in cm (best out of 3 jumps counts)
	Standing high jump (SHJ)	Difference between jumping height and maximal reaching height in cm
ENDURANCE	6-minute run (6MR)	Distance in meter in 6 minutes
COORDINATION	Lateral back- and forth jumping (LBFJ)	Number of jumps in 2 x 15 seconds (sum of both runs)
	Obstacles boomerang run (OBR)	Amount of time needed in seconds (2 runs are performed, faster run counts)

The percentile rank for the 20MR, SLJ, LBFJ and 6MR tests were calculated from the raw data using the normalised values of the German motor function tests (29). The percentile ranks for SHJ were calculated using the ‘Munich Fitness Tests (30). Raw data was used for PU and OBR, since no normalised values are available for the age group tested.

AD-EVA Questionnaire

AD-EVA is an interdisciplinary test system for the diagnosis and evaluation of obesity and other diseases that can be influenced by eating and movement life-style changes (31). This validated questionnaire covers nine main questionnaires (Scales) consisting of several sub-questionnaires (sub-scales) of which seven were analysed for this study. A detailed description of the scales is shown in Table 2. FEV-Path (pathogenic eating behaviour) was not included in the study, since the assumption was made that the

students were per se healthy. The FBEB (handling of food including carving and addiction) scale was excluded from analysis due to low response rates.

In order to achieve a standardisation, the evaluation tool of the standardized questionnaire (31) was used which compares the mean of the raw data values for each scale and subscale to the reference raw values of norm charts differentiating between age, sex and BMI. The corresponding T-value and percentage ranks as stated in (31) are reported. Participants were divided in three BMI groups. BMI-low (< 18.7, corresponding to the percentile groups P1-P3), BMI-norm (18.7-22.4, corresponding to the percentile groups P4-P6) and BMI-high (>22.4, corresponding to the percentile groups P7-P9). T-values have a range between 20 and 80, percentage ranks between 0 and 100. T values < 30/> 70 were considered extreme, 30 to < 40 as under average, 40 to < 60 as average and 60 to < 70 as over average. The equivalent percentage ranks allow a more concise interpretation of the T-values.

Table 2: AD-EVA questionnaire description including scales, description and subscales.

SCALE	DESCRIPTION	SUBSCALE
FUN	Self-estimate of carvings, uncontrollable urge for food (10 items)	
FEV-SALUT	Salutogenic behaviour (12 items)	- Sports (S- 4 items) - Ability of implementing suggestions (EU- 8 items)
FVE	Preclinical eating disorders (9 items)	- Preoccupation with weight and shape (PWS-7 items) - Symptoms (vomiting, purging, binge eating) (KV-2 items)
KINDL-R	Quality-of-life (24 items)	- Physical well-being (KW- 4 items) - Mental well-being (PW- 4 items) - Self-esteem (SW- 4 items) - Family (FAM- 4 items) - Friends (FREUND- 4 items) - School (SCHUL- 4 items)
FBM	Movement motivation (7 items)	- Fun and satisfaction (F&B- 5 items) - Aesthetics (Ä- 3 items)
EPL	Nutrition preference list (35 items)	- Healthy food (G- 12 items) - Hearty food (D- 7 items) - Snacks (S- 16 items)
SKB	Body image (5 items): six body images are shown from very slim to obese (1-6)	- 1. How do you see yourself? - 2. How would you like to be? - 3. How do you think others see you? - 4. Who is the most attractive? - 5. Who is the least attractive?

Data analysis

Laboratory data were managed and validated by the laboratory software GLIMS (MIPS Diagnostics Intelligence Europe, Gent, Belgium). All data including anthropometric, laboratory parameters and physical fitness values were imported to IBM SPSS Statistics version 25 (IBM Corporation, NY, US) and calculations and descriptive statistical analysis were performed. Data is presented as percentile (25, 50 and 75) to provide a better view of the distribution of the data. Statistical analyses between the control group and the intervention group were performed using the Independent Samples Mann-Whitney U Test with a significance level of $p < 0.05$ (Anthropometric, biomedical and PFTB) and independent sample test including Levene's test for equality of variances and t-test for equality of means (questionnaire). Statistical analyses between time points T0 and T2 were performed using the Paired-Sample Wilcoxon signed rank test including a Bonferroni correction (Anthropometric, biomedical and PFTB) and paired sample t-test (questionnaire).

Results

Participants and Compliance

In total, 109 students participated in the study (42 females and 67 males both aged 15.0 ± 0.7 years). Anthropometric data of 107 (40 females, 67 males), biomedical data of 104 (40 females and 64 males) and the PFTB data of 109 students (42 females and 67 males) were analysed (Table 3).

Dropout rates from the time point T0 to T2 differed for the different tests. For the anthropometric and PFTB data the dropout rate was 2.5% and 2.4% respectively for females and 4.7% for both data sets in males. For the laboratory measurements, the dropout rate was 7.5% and 6.3% for females and males, respectively. In case of missing values in the data range, the whole pair was excluded in the analysis comparing T0 and T2.

For the AD-EVA questionnaire we had a total of 38 females and 65 males, however, the groups were not split between control and intervention, since only one subscale (evaluation of fun and satisfaction (FBM-F&B)) resulted in a significant difference at T2 between the control- and intervention- group for the BMI-norm group in the male population out of all measurements.

Table 3: Number of participants (Control (Crtl) and intervention group (Int)).

	Female				*Male*			
	T0		T2		T0		T2	
	Crtl	Int	Crtl	Int	Crtl	Int	Crtl	Int
Anthropometric data	19	21	19	20	30	34	32	35
Biomedical data	19	21	19	18	31	33	30	30
PFTB	20	22	19	22	33	31	33	34

Anthropometric data

In Table 4 anthropometric data is shown for the start of the study at T0 for females and males, presented as 25, 50 (median) and 75 percentiles (control and intervention group combined). Detailed information including data for females and males at both time points can be found in the additional file 1. The analysis of the anthropometric data showed that the BMI is distributed according to the age- and gender-matched reference range. No statistical difference was observed between the control group and the intervention group at T0 and T2. To determine the change over time for the anthropometric data, statistical analysis was performed between the time point for both groups (Crtl and Int) in females and males (Table 4, Table S1). Over the period of 6 months, the male population showed a small, but significant increase in weight, height, BMI, waist- and hip circumference, whereas the female population showed only an increase in height, waist- and hip-circumference and hip/waist ratio (see Table 4 for group details). Interestingly, whole body bio-impedance as well as right and left arm bio-impedance was significantly lower at T2 in males (Table 4). This could be explained as a result of the increase in physical fitness shown in Table 5.

Table 4: Anthropometric data.

	Female					Male				
	Percentile (T0)			T0 vs T2		Percentile (T0)			T0 vs T2	
	25	50	75	Ctrl	Int	25	50	75	Ctrl	Int
Weight (kg)	49.8	54.8	63.8	-	-	54.7	62.1	72.3	↑	↑
Height (cm)	159.3	165.0	168.9	↑	-	168.0	174.8	179.0	↑	↑
BMI	18.1	20.5	22.7	-	-	18.7	20.4	22.7	↑	↑
BMI SDS	-0.89	-0.08	0.57	-	-	-0.51	0.04	0.67	-	-
Waist circ (cm)	64.5	68.3	72.4	↑	↑	68.3	72.0	77.1	↑	↑
Hip circ (cm)	84.0	89.3	93.4	-	↑	79.3	86.5	93.0	↑	↑
Hip/Waist ratio	0.7	0.8	0.8	↑	-	0.8	0.9	0.9	-	-
Upper thight circ (cm)	44.0	46.8	50.4	-	-	44.0	47.0	51.4	-	-
Neck circ (cm)	24.1	25.0	26.8	-	-	26.5	28.0	29.4	-	-
BIA-whole body (Ω)	696	747	794	-	-	568	619	667	-	↓
BIA-right leg (Ω)	277	302	315	-	-	239	257	275	↓	↓
BIA- left leg (Ω)	281	301	319	-	-	238	255	276	-	-
BIA-right arm (Ω)	381	403	432	-	-	306	338	365	-	-
BIA-left arm (Ω)	389	418	445	-	-	319	340	370	↓	↓

Legend Table 4: Data is shown as median, 25 and 75 percentiles for females and males at T0 (control and intervention group combined). Statistical analysis was performed between the time points T0 and T2 in females and males in the control group and the intervention group (- no significant change between time points, ↑ significant increase, ↓ significant decrease). BIA: Bioimpedance analysis; circ: circumference.

Results PFTB

Physical fitness of the participants was assessed by the standardized age- and percentile-matched physical fitness test battery (PFTB). Standardized PFTB data is shown for the start of the study at T0 for females and males, presented as 25, 50 (median) and 75 percentiles (Table 5) (Crtl and Int combined). Detailed information including data for females and males (Crtl and Int group) at both time points can be found in the additional file 2. Statistical difference between the control and intervention group at both time points was determined. At T0 the intervention group of the male population showed by chance a significantly higher number of PU compared to the control group (p=0.012). Percentile ranks (20MR, SLJ, SHJ, 6MR, LBFJ- as described in the section material and methods) and raw data (PU and HU) are shown for females and males at T0.

To determine the change over time for the PFTB data, statistical analysis was performed between the time point T0 and T2 for both groups (Crtl and Int) in females and males (Table 5, Table S2). Over the period of 6 months, the female population showed a significant improvement at the exercises PU, LBFJ and OBR and the male population at the exercises 20MR, PU, LBFJ and OBR (for group details see Table 6).

Table 5: PFTB results shown as percentile ranks (except for PU and HU).

	Female					*Male*				
	Percentile (T0)			T0 vs T2		Percentile (T0)			T0 vs T2	
	25	50	75	Ctrl	Int	25	50	75	Crtl	Int
20 MR	34.0	60.0	86.0	-	-	62.5	86.0	92.0	↑	-
PU (n)	9.0	10.0	12.0	↑	↑	12.0	14.0	15.8	↑	↑
SLJ	59.5	84.0	96.0	-	-	44.0	78.0	90.0	-	-
SHJ	21.0	50.0	79.0	-	-	34.0	54.0	73.0	-	-
6MR	75.0	90.0	94.0	-	-	46.0	58.0	82.0	-	-
LBFJ	36.0	48.0	66.0	-	↑	36.0	50.0	66.0	-	↑
OBR (sec)	14.6	15.9	17.4	↑	↑	13.7	14.4	15.5	↑	↑

Legend Table 5: Median, as well as 25 and 75 percentiles at T0 are shown for females and males (control and intervention group combined). Statistical analysis was performed between the time points T0 and T2 in females and males in the control group and the intervention group (- no significant change between time points, ↑ significant improvement, ↓ significant decrease/decline).

Biomedical parameters

The biomedical parameters measured in this study included blood values, carbohydrate metabolism, fat metabolism, thyroid hormones, renal function parameters, liver function parameters, vitamins and hormones. A detailed description of the biomedical parameters measured in this study at time point T0 were published previously by Bogner *et al.* 2019, reporting the data as paediatric reference intervals for an Austrian cohort (26). In the present manuscript, we focused on the changes of the biomedical parameters over time and the differences between control and intervention group.

Statistical difference between the control and intervention group at both time points was determined for all parameters measured. At T0 the intervention group in the female population had significantly lower values for FT3 (p=0.012), FT4 (p=0.008) and SHBG (p=0.01) (data not shown) and at T2 for glucose

(p=0.039). The male population had significantly lower values in the intervention group for neutrophils (p=0.02), lymphocytes (p=0.017) (data not shown), HbA1c (p=0.026), albumin (p=0.048) and adiponectin (p=0.021) at T2. Since the groups were chosen randomly, the significant differences at T0 are purely by chance. To determine the change over time for the laboratory parameters, statistical analysis was performed between the time point T0 and T2 for both groups in females and males. Out of the 50 parameters 14 parameters, mainly linked to haematology, carbohydrate metabolism, fat metabolism and renal function, showed a significant change over time in one or more of the groups measured (Table 6). Interestingly, with the exception of ApoA1 and urea, the significant changes over time in the male population only occurred in the intervention group. Detailed information including data for females and males (Crtl and Int group) at both time points as well as reference ranges (Bogner et al., 2019) can be found in the additional file 3.

Table 6: Biomedical parameters.

	Female					*Male*				
	percentile			T0 vs T2		percentile			T0 vs T2	
	25	50	75	Ctrl	Int	25	50	75	Ctrl	Int
Erythrocytes (x10^6/μl)	4.4	4.6	4.8	↓	-	4.9	5.1	5.3	-	↓
Haemoglobin (g/dl)	12.5	13.4	13.9	↓	↓	14.3	14.9	15.4	-	↓
HCT % (%)	38.0	39.9	40.7	↓	-	41.8	43.2	44.8	-	↓
MCH (pg)	27.9	29.0	29.9	-	↓	28.5	29.1	29.6	-	-
Monocytes (%)	5.3	5.7	6.8	-	-	5.4	6.4	7.4	-	↑
Glucose (mg/gL)	77.3	81.0	84.8	↑	-	81.0	85.0	87.0	-	-
Insulin(μIU/ml)	8.7	10.1	13.9	-	-	8.8	10.5	13.4	-	↓
LDL (mg/dL)	72.6	95.1	118.9	-	-	79.8	92.7	109.0	-	↓
LDL prop HDL	1.2	1.5	2.1	-	↓	1.4	1.6	2.1	-	-
ApoA1 (mg/dL)	148.2	166.2	179.4	-	-	137.6	152.7	160.9	↓	↓
Adiponectin (μg/ml)	8.7	10.3	12.4	-	-	7.1	9.7	11.5	-	↓
Albumin (g/L)	47.3	49.2	51.7	-	-	48.5	50.7	53.0	-	↓
Creatinine (mg/dL)	0.6	0.7	0.8	-	-	0.7	0.8	0.9	-	↑
Urea (BUN (mg/dL)	18.8	21.8	25.7	-	-	21.4	24.4	29.1	↑	↑

Legend Table 6: Data is shown as median, 25 and 75 percentiles for females and males at T0 (control and intervention group combined). Statistical analysis was performed between the time points T0 and T2 in females and males in the control group and the intervention group (-no significant change between the time points, ↑ significant increase (p≤ 0,05), ↓ significant decrease (p≤0,05)). Out of the 50 parameters tested, only those with a significant change are shown.

AD-EVA Questionnaire

The prevalence of various eating and movement behaviour patterns was assessed by the validated and standardized age- and percentile-matched AD-EVA questionnaire. The analysis was based on the BMI of participants as proposed by the AD-EVA manual. The participants were divided into three BMI groups including BMI-low (< 18.7, corresponding to the percentile groups P1-P3), BMI-norm (18.7-22.4, corresponding to the percentile groups P4-P6) and BMI-high (>22.4, corresponding to the percentile groups P7-P9). Statistical difference between the control and intervention group at both time points was determined for each BMI- and gender- group. Out of the 17 subscales investigated, only the subscale 'Movement motivation- Fun and satisfaction' (FBM-F&B) in the BMI-norm group of the male population resulted in a significant difference at T2 ($p < 0.011$). Therefore, the analysis was performed by combining the control group and intervention group. Each of the 17 subscales were further tested for statistical significance between the time points for male and females in each BMI group. In the male BMI-low group, 'Nutrition preference list- Snacks' (EPL-S) ($p< 0.036$) and 'Nutrition preference list (snacks, healthy and hearty/fatty food)- SUM' EPL-SUM ($p< 0.018$) were significantly decreased at T2. In the male BMI-high group, 'Nutrition preference list- hearty food' EPL-D and EPL-SUM were significantly decreased ($p< 0.008$) and in the female group 'Preclinical eating disorder- ability of implementing suggestions' (FEV-EU) was significantly increased ($p< 0.011$) at T2. Furthermore, the results of the overall scales (EPL, FEV, FVE, KINDL, FBM) (sum of subscales) were presented as mean and standard deviation in Table 7 with the corresponding percentage range and T-value as defined by the AD-EVA manual (31). The T-values for the scales 'Self-estimate of carvings, uncontrollable urge for food' (FUN), 'Salutogenic behaviour' (FEV), 'Preclinical eating disorders' (FVE) and 'Movement motivation' (FBM) were within the healthy average range (40 to <60), except the female BMI-high group with a T-value of 38 for the corresponding age and BMI reference group. The T-value of 'Nutrition preference list' (EPL) was below 30 for all groups analysed (corresponding to their BMI percentile) which is considered extreme. The T-value results of the 'Quality-of-life' (KINDL) questionnaire were classified as below average for the BMI-low and the BMI-norm group and average for the BMI-high group. 'Body image' (SKB) results for T0 are presented as mean and standard deviation for each item (Table 8). Detailed description of the 'Body image' questionnaire can be found in Table 2 and Table 8. All values were between 2.5 and 3.8, which is considered an average response

indicating no disorder in terms of body image. Interestingly, the results for item 5 ('who is the least attractive') had a substantial spread ranging from 1-6 with a standard deviation close to the mean (Table 8). No significant differences were observed between T0 and T2, therefore only T0 is shown in Table 8.

Table 7: AD-EVA questionnaire.

		Female				*Male*				
	SUM	Mean	SD	PR	T-value	Mean	SD	PR	T -value	Ref. range
BMI-norm	FUN	20.3	6.9	77	57	17.7	5.6	69	55	P1-P5 (m/f)
	EPL	71.2	24.8	2	29	69.3	16.5	2	28	P1-P5 (m/f)
	FEV	49.0	6.4	68	55	46.3	5.1	53	51	P1-P9 (m/f)
	FVE	18.8	7.1	59	52	16.4	6.3	68	55	P1-P9 (m/f)
	KINDL	71.8	7.9	6	35	70.1	4.0	5	34	P5 (m)/(f)
	FBM	30.4	5.8	58	52	30.6	4.1	58	52	P1-P5 (m/f)
BMI-low	FUN	16.9	4.1	65	54	20.3	5.9	77	57	P1-P9 (m/f)
	EPL	87.0				67.6	9.6	1	28	P1-P5 (m/f)
	FEV	45.0	7.1	48	49	46.0	4.6	53	51	P1-P9 (m/f)
	FVE	20.6	4.3	92	64	13.8	3.4	66	54	P1-P9 (m/f)
	KINDL	68.7	1.8	5	33	71.8	4.4	6	35	P1-P4 (m/f)
	FBM	26.7	7.4	35	46	28.8	3.3	46	49	P1-P5 (m/f)
BMI-high	FUN	22.8	6.8	73	56	21.6	6.5	70	55	P1-P9 (m/f)
	EPL	62.0				64.1	9.6	1	27	P7 (m/f)
	FEV	47.8	5.0	63	53	46.5	4.4	58	52	P1-P9 (m/f)
	FVE	20.0	4.7	13	38	19.1	6.2	33	46	P1-P9 (m/f)
	KINDL	69.6	5.3	19	41	73.2	4.7	24	43	P7 (m)/(f)
	FBM	29.5	4.4	52	51	29.1	2.3	52	51	P8 (m/f)

Legend Table 7: Descriptive values from all students at time point T0 for the scales FUN, EPL, FEV, FVE, KINDL and FBM presented as mean and standard deviation as well as the corresponding percentage range and T-value for each for the BMI groups (BMI-norm, BMI-low, BMI-high) in both gender.

Table 8: AD-EVA questionnaire- SKB scale.

SKB	*BMI-norm*				*BMI-low*				*BMI-high*			
	Female		Male		Female		Male		Female		Male	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. item	3.3	0.7	3.8	0.9	3.3	0.7	3.8	0.9	3.3	0.7	3.8	0.9
2. item	2.5	0.5	2.9	0.5	2.5	0.5	2.9	0.5	2.5	0.5	2.9	0.5
3. item	2.9	0.6	3.8	0.7	2.9	0.6	3.8	0.7	2.9	0.6	3.8	0.7
4. item	2.5	0.5	2.8	0.5	2.5	0.5	2.8	0.5	2.5	0.5	2.8	0.5
5. item	2.7	2.9	3.0	2.6	2.7	2.9	3.0	2.6	2.7	2.9	3.0	2.6

Legend Table 8: Descriptive values from all students at time point T0 for the scale SKB presented as mean and standard deviation for the BMI groups (BMI-norm, BMI-low, BMI-high) in both gender. 1. *item- How do you see yourself*? 2. Item- *How would you like to be*?, 3. Item- *How do you think others see you*?, 4. Item- *Who is the most attractive*?, 5. Item- *Who is the least attractive*?.

Discussion

The study was designed to assess the potential of an interdisciplinary life-style program on the health status of adolescents over a 6-month period. The focus was placed on the changes observed over time including anthropometric, biomedical, and physical fitness parameters as well as the results of the AD-EVA questionnaire. The results are reported as a comparison of the measured parameters at the start and the end of the study. Control and intervention group are presented separately in order to identify a potential impact of the intervention tool “hand-on workshops”.

In terms of the adoption variable, the intention to employ a new intervention in this specific school setting was met with great acceptance from the head of school and teachers, participants and their parents as well as the ethics committee and policies involved. This positive adaption was also linked to a high feasibility of the program.

In terms of the study aims acceptability and appropriateness, the program was well accepted by the participants, with a dropout rate of maximally 7.5% and a general positive feedback of the participants was received. The study population was selected to show effects of the intervention rather than selecting beneficiaries, since such a life-style program is aimed at the wide variety of young adolescents without particular comorbidities or specific social, cultural or economic environment.

An extensive part of the program was linked to the degree to which participants might benefit from this intervention. The results of the anthropometric data revealed a significant increase in weight, height and BMI, as well as hip-, waist- and neck-circumference over the course of 6 months within the normal reference range. This can be explained by the continuous growth in adolescence. Interestingly, the

increase was more pronounced in the male population in both the control and intervention group, compared to the female population. Moreover, a significant decrease in whole body- as well as right- and left-arm-bio-impedance measurement results was observed after 6 months, implying an increase in muscle mass paralleled by a decrease in fat mass. This can be linked to a significant increase in physical fitness related to pull ups, coordination and motor skills, caused by the repeated analysis of these measures in both groups. In addition, the muscle metabolite creatinine was significantly increased in the male intervention group, indicating a potential increase in muscle turnover and physical activity (32).

Moreover, the earlier findings focussing on the calculation of reference intervals of haematological and biochemical markers in an Austrian adolescent study cohort were extended in the present report (26). Various clinical laboratory parameters were measured at different time points. The comparison of the parameters at T0 and T2 showed significant changes in the haematological values and parameters for the determination of carbohydrate- and fat-metabolism as well as renal function. The number of erythrocytes, as well as the haemoglobin, haematocrit and mean corpuscular haemoglobin values were significantly decreased, nevertheless all values were still in the normal reference range (Table 6 and Table S3). These changes might be due to daily fluctuations, especially for the female population (33). Some of the values indicated, that changes might be due to an enhanced physical activity, a direct connection cannot be drawn at this stage and this should be studied in more detail. Nevertheless, a study investigating the effects of exercise and training on the oxygen supply of red blood cells showed, that trained athletes have a decreased haematocrit which is brought about by an increased plasma volume (34). Changes in the carbohydrate metabolism were observed for glucose and insulin values in only a number of female and male participants, which could be due to a specific diet before the day of the measurement. However, no long-term conclusion can be drawn from these observations. A connection between dietary changes and a long-term modulation of the carbohydrate metabolism can only be drawn if there would have been a significant change in glucose-, insulin- and HbA1c values within one of the groups (35, 36). Interestingly a number of fat metabolism-related parameters decreased significantly over the course of the study, mainly in the intervention group of the male population, whereby all changes remained in the normal reference range. Parameters included LDL-cholesterol, LDL/HDL ratio, ApoA1 and Adiponectin. A decrease in LDL-cholesterol concentration and LDL/HDL ratio indicates a general positive trend towards a healthier lifestyle, whereby a decrease in adiponectin, a hormone which is involved in regulating glucose levels as well as fatty acid breakdown, indicates an increase in fat cell depot and fat cell size (37). This is in contrast to the observed results for whole body- as well as right- and left- arm bio impedance, which implied an increase in muscle mass paralleled by a decrease in fat mass. This could be explained by daily fluctuations of the adiponectin level in contrast to a more consistent change of bio-impedance over the 6 month time point (38). A study investigating the lifestyle and dietary determinants of serum apoA1 and apoB concentrations showed that high intake of products containing added sugar, such as pastries, sweets, chocolate, jam/sugar and sugar-sweetened beverages, was associated with lower ApoA1 concentrations but higher ApoB concentrations and a higher ApoB/ApoA1 ratio (39). In our study, the concentration of ApoB did not change significantly over time.

In order to further evaluate the psychological state of the adolescents in relation to their eating habits, a psychologically approved questionnaire was included in this study (31). Statistical analysis showed, that only a very limited effect was seen between the control group and the intervention group after the 6 months period, indicating a low impact of the nutrition workshop on the eating habits. Therefore, results were further analysed as control- and intervention-group combined. Some of the questionnaires scales and subscales significantly changed over the course of the study. A significant decrease was observed in 'Nutrition preference list- snacks, hearty and SUM' (EPL-S, EPL-D and EPL-SUM), which indicates a decreased consumption of snacks, hearty food and an overall decrease in the ratings of snacks, hearty and healthy food, respectively. A significant increase was observed for 'Salutogenic behaviour- Ability of implementing suggestions' (also known as FEV-EU), which indicates an increased ability of implementing suggestions. In general, the changes indicate a trend towards slightly healthier eating habits by the reduction of snacks and hearty food. However, no significant increase in healthy food was observed and all changes happened only in a subgroup of participants. In addition, it should be mentioned that the results of the 'Nutrition preference list' (EPL) scale, presented as T-values, are classified as 'extremely below the average' compared to the reference group defined by (31). This is due to the fact, that the participants rated the list of products including snacks, hearty and healthy food with an average of 'neither…nor' (3) or 'not really' (2) which resulted in the low overall value.

The T-value results of the 'Quality-of-Life' (KINDL) questionnaire were classified as below average for the BMI-low and the BMI-norm group which would indicate a reduced quality of life compared to the reference values of adolescents with a similar weight range. Regarding the 'Body image' (SKB) scale, the results are within the normal range. Interestingly, for item 5- who is the least attractive- the answer was very diverse ranging from the skinniest person to the chunkiest person.

By the use of this questionnaire, we aimed to evaluate the eating behaviour or change of diet over the course of the study, however we did not expect a substantial change in the outcome of the questionnaire comparing the start and the end of the study since our study participants were not considered to have an eating disorder in any of the scales tested.

A number of limitations have to be considered when interpreting the results. Especially the biomedical parameters have to be judged carefully, since these values are mainly linked to a healthier lifestyle in terms of intake of healthy food. In this study, we could not control for the availability of healthy food including the school buffet or the consumption of fruits and vegetables as snacks provided by the parents (40). In addition, the supportiveness of the school environment and at home to live a healthier lifestyle should be given and this factor could also not be influenced in this study (21).

Nevertheless, the results demonstrate a positive effect of the performed dietary- and lifestyle-program in terms of body fat, muscle mass and physical activity. A Trend was shown towards a healthier lifestyle regarding muscle metabolism through the creatinine pathway and fat metabolism via a decrease in LDL levels and the LDL/HDL ratio. In addition, the measurement of a set of biomedical parameters facilitate

an early detection of physical deficiency symptoms, e.g. anaemia or hyperlipidaemia, which allows for an early therapeutic intervention.

Some of these positive changes were more pronounced in the intervention group and some were present in both the control and the intervention group. These findings demonstrate that measuring the health status and confronting young people with their well-being might have a positive effect on their well-being and self-empowerment.

Conclusion

Early information and prevention programs in schools, in order to increase the awareness of a healthy lifestyle including dietary health as well as physical health, have a number of important implications. The implementation of such projects as permanent topics in the school curriculum over an extended period of time could improve the health of students, leading to less days of absence from classes, an increased ability for self-perception and self-reflection as well as self-empowerment.

Even though this study lasted only 6 months, we could already detect a positive impact on the health status of the students by an increase in physical fitness and increased awareness for nutrition and beverages as well as health-associated parameters. In addition, the fact that the students had regular interrogations regarding their health status and fitness might per se lead to an increased awareness and subsequently positive effect.

List Of Abbreviations

Ability of implementing suggestions (EU), Aesthetics (Ä), Body mass index (BMI), Body image (SKB), Control group (Crtl), Family (FAM), Friends (FREUND), Fun and satisfaction (F&B), Healthy food (G), Hearty food (D), Intervention group (Int), Lateral back- and forth jumping (LBFJ), Mental well-being (PW), Movement motivation (FBM), Nutrition preference list (EPL), Obstacles boomerang run (OBR), Quality-of-life (KINDL-R), Salutogenic behaviour (FEV-SALUT), School (SCHUL), Self-esteem (SW), Self-estimate of carvings, uncontrollable urge for food (FUN), Sports (S), Snacks (S), Standing high jump (SHJ) , Standing long jump (SLJ), Symptoms (vomiting, purging, binge eating) (KV), Physical fitness test battery (PFTB), Physical well-being (KW), Preclinical eating disorders (FVE), Preoccupation with weight and shape (PWS), Pull-ups (PU), 6-minute run (6MR), 20-meter run (20MR).

Declarations

Ethics approval: The ethics commission approved the study including project description and consent form of participants. Name of the ethics committee- *Ethikkommission Land Salzburg*, committee's reference number- 415-E/1758/19-2015 (Votum 2). The research was performed according to the Declaration of Helsinki.

Consent to participate: Consent form to participate in the study was obtained from of all participants (or their parent or legal guardian in the case of children under 16).

Consent to publish: We obtained consent to publish from the participant (or legal parent or guardian for children) to report patient data.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests

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Authors' contributions: "AS analyzed and interpreted the patient data and was a major contributor in writing the manuscript. KS organized and participated in the data acquisition and analyzed the patient data. EO was strongly involved in the organization and performance of the study in the school setting.

GL supported the study design, ethical approval and dissemination phase of the project concerning the statistical aspects. EAG provided and analyzed the psychological questionnaire used in this study.

DW supported all medical parts of this study, including obtaining the ethical approval, informing the students and parents and interpreting the medical data. SRD designed and provided the sports related part of this study. TF supervised, organized and analyzed the sports related part of this study. GJO designed the study, analyzed and interpreted the patient data and contributed in writing the manuscript. BB Designed the study, analyzed and interpreted the patient data and contributed in writing the manuscript.

All authors read and approved the final manuscript.

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