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An Exploratory Analysis of the Effects of Interventions in Active Mobility to School on the Body composition and Physical Efficiency of 14- 18-year-old Adolescents in Five European Countries

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Abstract

The well-being and physical health of children and adolescents is a crucial topic that is related to several factors such as physical activity level, nutrition, and socioeconomic status in different countries. This study aims to analyze the effectiveness of shifting from passive to active mode choice on improving physical efficiency and body composition of adolescents aged 14-18 years old in five European countries; Poland, Greece, Italy, Croatia, and Turkey. This paper has three research questions. (1) is there any association between the body composition of adolescents of 14 to 18 years including fat, Fat-Free Mass, Total Body Water, Body Mass Index, VO2 max., and physical efficiency after the intervention in their mobility to school in European or in national level? (2) are there any significant changes in the physical efficiency of the participants after using more active mode choice to school at the European or national level? (3) are there significant associations between the duration of intervention school mobility and body composition factors or physical efficiency? For answering the two first research questions, T-tests and Chi-square tests were applied to assess the changes in body composition and physical efficiency. The findings show that body efficiency has improved by shifting to active transportation at both the national and international levels. The Ordinary Least Squares (OLS) regression was generated to answer the third research question and determine the correlations between intervention duration and body composition. The amount of fat change after the intervention is significantly associated with the intervention time. The other body composition variables are not related to intervention time.

Keywords: Body composition, physical efficacy, intervention, active transportation, European countries

1. Introduction

The deeper focus on the role of nutrition and physical activity is a result of the increased public attention to the rise in childhood obesity. Child and adolescent l health correlate with different socioeconomics, physical activity, travel behavior, nutrition, academic performance in school, and parent's perception. Also, it can rely on the political and economic systems in different countries. Low levels of physical activity and metabolic fitness and obesity are risk factors for cardiovascular disease and diabetes. Obesity is the one of important risk factors for heart disease (Donnelly et al. 1996; Chomitz et al. 2009; van Dusen et al. 2011). The increase in physical inactivity is one of the main causes of the increase in obesity between children and adolescents (Singh et al. 2008). Sedentary behavior is related to increases in body mass index (BMI) and, increased risk of type 2 diabetes (Donnelly et al.

2009). Unfortunately, schools suffer usually from difficulties and barriers to interventions to promote physical activity.

Several studies assessed the impacts of the intervention on the physical and mental health of children and adolescents through special diet programs or physical activities. Gortmaker et al. (1999) evaluated the influences of a school-based health behavior intervention on diet and physical activity among schoolchildren. The results of that study showed the positive impacts of the intervention on reducing total energy from fat and saturated fat among students. The impacts of a school-based physical activity program on the physical and mental health of schoolchildren were assessed in Switzerland for a year. According to the results of this study, a school-based physical activity intervention enhanced the level of physical activity and fitness and reduced adiposity in children (Kriemler et al. 2010). Also, positive and short-term changes in reducing the BMI of pupils were seen among the intervention group in a school-based program in Greece (Manios et al. 1999). Donnelly et al. (2009) studied the impacts of adding a three-year physical activity to the curriculum of schools. The findings of that study indicated that physical activity across the curriculum approach probably promotes daily activity in elementary school children and reduces BMI. Pan et al. (2017) showed a 12-week physical activity intervention has positive results in improving motor skills in children with an autism spectrum disorder.

Physical activity in adolescence may associate with the development of healthy behavior, helping reduce chronic disease. Hallal et al. (2006) discussed the optimal amount of physical activity in adolescents for improving adult physical health is ambiguous. Although there is a considerable number of studies on the impacts of the intervention on physical health, there are shortcomings in the association between intervention duration and gaining positive results in physical health. Heath et al. (2012) reviewed physical activity interventions that were published between 2000 and 2011. The informational, behavioral, and social approaches are the most effective intervention ways. Also, school-based strategies like adding physical education to the curriculum, classroom activities, after-school sports, and active transport were identified as effective intervention methods for increasing physical activity in children and adolescents (Heath et al. 2012).

Active mobility is one of the ways for increasing daily physical activity and public health. The improved health and quality of life as a result of increasing walking and cycling were demonstrated by employing a meta-analysis of health-impact assessments in Europe, North America, Australia, and New Zealand (Mueller et al. 2015). Mueller et al. (2017) investigated the impacts of urban and transportation planning in promoting physical activity and reducing mortality in cities. The findings of that study confirmed that the increases in active mobility and the reduction of motorized traffic contribute to increase in the average life expectancy by reductions of exposure to air pollution, traffic noise, and heat. Another investigation estimated the benefits of shifting passive to active transportation in Italy. That study showed the positive impacts associated with increased physical activity outweigh the damages related to increased air pollution intake and road accidence risk for all active transportation considered (Mela and Girardi 2022). Stark et al. (2018) showed parents' attitudes influence on mode choice of schoolchildren for commuting. Westman et al. (2013) studied the level of activation among schoolchildren. The findings of that study showed that children who use motorized mode choices for traveling have fewer physical activities than those who use active mode choices for commuting. Also, for motorized commuters, girls have less chance than boys for having physical activities during the day. Another investigation on assessing the level of physical activity and sedentary behavior among schoolchildren indicated active travel to school was not correlated with children's physical activity, but active mobility in non-school destinations was associated with moderate-to-vigorous physical activity and health (Schoeppe et al. 2015). The positive association between active school travel and muscular fitness was confirmed among youth by Cohen et al. (2014). According to that study, cycling as the dominant mode choice for school travel played an important role in youth health. An investigation on the relationship between physical activity and BMI among adolescents in Norway showed a high level of physical activity was associated with low-back pain and high BMI (Sjolie 2004). Trost et al. (2001) discussed that there is a positive association between physical inactivity and childhood obesity. Hills et al. (2011) indicated that a large number of children and adolescents with less amount of physical activity have a higher level of body fat than those who are more active. However the relationship between active mobility and physical health was studied by scholars, and the impacts of shifting from passive to active mode choice are still ambiguous for different socioeconomic groups.

Although, there is a strong body of literature on determinants of active mobility or the relationship between physical activity and public health. Our knowledge of the association between active transportation as a way of increasing physical activity and public health features suffers from shortcomings in different socioeconomic groups and different parts of the world. The quality of public health is associated with various factors including body mass index, gender, age, the proportion of water, percentages of fat, and fat-free mass. Although these body composition features determine the quality of health together, most studies concentrated on the association between physical activities and one or two factors of health like obesity and BMI. In addition, socioeconomic features play an important role in the level of physical activity and public health. So, there is a need for more studies to consider different cities and countries for providing deep and consistent literature on public health.

The main objective of the current paper is to determine the relationship between active transportation and the physical health of adolescents of 14 to 18 in five European countries. Assessing the impacts of travel behavior changes from passive to active mobility on the physical efficiency of adolescents is another objective of this paper. Also, the current paper aims to assess the influences of travel changes on physical efficiency for each case study separately to generate a better understanding of each European country and the total sample size of European countries in this study. The last but not least aim of this study is to find out the association between the intervention period (the number of days for travel behavior change) and physical efficiency.

To reach research objectives, the rest of this paper is organized as follows. Section 2 outlines the methods applied in the paper. In Section 3, we present the results and main findings. Section 4 provides a thorough discussion of the major findings of the association between physical activity and physical efficiency in adolescents. Finally, section 5 presents the conclusions.

2. Methodology

2.1. Research Questions and Hypotheses

This study was designed to answer the following research questions: (1) are there any significant changes in the body composition of adolescents of 14 to 18 years including fat, Fat-Free Mass, Total Body Water, Body Mass Index, VO2 max., and physical efficiency after the intervention in their mobility to school in European or in national level? (2) are there any significant changes in the physical efficiency of the participants after having (Mueller et al. 2015) more active transport to school at the European or national level? and finally (3) are there significant correlations between the duration of intervention school mobility and body composition factors or physical efficiency?

The paper is built on the following hypothesis: changing the school mobility mode of adolescents from motorized transportation to active transport (walking and biking) can have positive effects on the body composition and physical efficiency of adolescents of 14 and 18 years in European countries. The duration of time of this change is important for some of the indicators of body composition.

2.2. Data and Variables

This study applies the data collected by a European Commission-funded project named "Promotion of Physical Activity of the Youth through Active Mobility to School" focusing on adolescents of 14-18 years in five European countries, namely Italy (Sassari), Greece (Thessaloniki), Poland (Krakow), Turkey (Malatya), and several cities in Croatia. The respondents were interviewed twice once before the intervention and once after it. In mid-2022, the responses of the interviewees havcollected about 40 questions, which were made up of a combination of a non-standard questionnaire about individual and household characteristics, perceptions about the urban environment (20 questions), and the short version of the standard survey instrument called International Physical Activity Questionnaire (IPAQ).

The sample included 990 respondents including 188 adolescents in Sassari, Italy; 244 in Thessaloniki, Greece; 247 in Krakow, Poland, 153 in Malatya, Turkey, and 158 in Croatia.
To answer the research questions of this study, seven independent variables of age, height (cm), weight (kg), household size, household car ownership, number of people with a job outside the home, and the length of time of living in the current home were taken as explanatory variables (Table 1 and 2). The variables in question including six continuous variables and one categorical variable were applied. The continuous variables include weight (kg), Fat (%), Fat-Free Mass (kg), Total Body Water (%), Body Mass Index, and VO2 max. (ml/kg/min) were taken to reflect the body composition of the adolescents. The parameters characterizing the body's oxygen potential (VO2 max.) were calculated computationally from the nomogram by combining the lines of HRO2 (oxygen heart rate values) with the value of the work done and body weight (kg). Apart from VO2, the rest of the dependent variables were quantified using the body composition analyzer TANITA BC 420. These included Body Weight (kg), Fat% as the amount of body fat as a proportion of body weight (%), Fat-Free Mass (FFM), which is comprised of muscle, bone, tissue, water, and all other fat-free mass in the body (kg), Total Body Water (TBW) representing the amount of water retained in the body. TBW is often between 50% to 70 % of total body weight. Generally, men tend to have higher water weight than women due to a greater amount of muscle. Body Mass Index (BMI) was calculated by dividing weight (kg) by height (cm) multiplied by 100. The only categorical explanatory variable was the physical efficiency, which was estimated by the ASTRAND-Rhyming test, the results of which classified the efficiency of the participants into seven categories of very poor, poor, fair, average, good, very good, and excellent during and after the intervention. The means, number of subjects, and standard deviations of these variables before and after the intervention of this study have been reflected in Table 3. The physical efficiency of the participants in different countries has been summarized in Table 4.

Table 1. Variables

Variable	Description
Age	This variable is extracted from questionnaires. Participants were 14 to 18 years old.
Household size	This variable is extracted from questionnaires. The number of people who live in the same house.
Number of people with job	This variable is extracted from questionnaires. The number of people with jobs in participants' homes.
Car ownership	This variable is extracted from questionnaires. The number of cars in the household.
Length of time of living in the current home	This variable is extracted from questionnaires. The number of years for living in the current home.
Fat %	Fat is the amount of body fat as a proportion of body weight.
Fat-Free Mass (FFM)	FFM is the term used to describe all the tissues in the body that are not adipose (fat) tissue. FFM includes most of the body's vital tissues and cells. (Janiszewska R., 2013)
Total Body Water (TBW)	TBW percentage is the total amount of fluid in a person's body expressed as a percentage of their total weight. (Janiszewska R., 2013)
Body Mass Index (BMI)	BMI is a measurement of a person's leanness or corpulence based on height and weight and is intended to quantify tissue mass. (Janiszewska R., 2013)
VO2 Max	VO2 max, or maximal oxygen consumption, refers to the maximum amount of oxygen that an individual can utilize during intense or maximal exercise. (Kubica R., 1995; Jaskólski A., 2002)

Table 2: The descriptive statistics of the explanatory and dependent variables (N=990).

Variable Type	Variable	N	Minimum	Maximum	Mean	Std. Deviation	Variance

Explanatory	Age	957	14	18	15,89	1,25	1,56
	Household size	990	0	10	4,18	1,24	1,53
	Car ownership	990	0	10	1,68	1,02	1,04
	Number of people with job	990	0	7	1,88	0,83	0,69
	Length of time of living in the current home	990	0	50	11,84	5,96	35,51
Variables in Question Before and After Intervention	Fat 1 (%)	223	3	51	21,12	10,41	108,46
	Fat 2 (%)	207	3	50	21,14	10,50	110,30
	Fat-Free Mass 1 (kg)	286	24	77	49,29	9,01	81,24
	Fat-Free Mass 2 (kg)	270	24	76	49,22	9,03	81,51
	Total Body Water 1 (%)	223	26	71	51,71	11,04	121,80
	Total Body Water 2 (%)	211	25	71	50,92	10,90	118,77
	Body Mass Index 1	285	15	33	21,68	3,37	11,33
	Body Mass Index 2	273	10	33	21,62	3,29	10,81
	VO2 Max. 1 (ml/kg/min)	270	19	66	37.12	8.51	72.39
	VO2 Max. 2 (ml/kg/min)	267	17	66	38.04	8.52	72.61

Table 3: The means of body composition variables for the five case countries.

Country	**Body composition variable**	**Mean**	**N**	**Std. Deviation**	**Country**	**Body composition variable**	**Mean**	**N**	**Std. Deviation**
Croatia	Fat 1 (%)	33.63	47	10.507	Italy	Fat 1 (%)	17.50	52	7.439
	Fat 2 (%)	33.62	47	10.397		Fat 2 (%)	16.66	52	6.929
	Fat-Free Mass 1 (kg)	40.21	47	9.078		Fat-Free Mass 1 (kg)	54.66	52	7.252
	Fat-Free Mass 2 (kg)	40.30	47	9.025		Fat-Free Mass 2 (kg)	53.31	52	7.118
	Total Body Water 1 (%)	52.54	47	6.383		Total Body Water 1 (%)	53.72	52	6.030
	Total Body Water 2 (%)	52.63	47	6.282		Total Body Water 2 (%)	53.02	52	3.231
	Body Mass Index 1	22.80	47	3.290		Body Mass Index 1	22.41	51	4.041
	Body Mass Index 2	22.70	47	3.139		Body Mass Index 2	21.90	51	4.261
	VO2 Max. 1 (ml/kg/min)	34.67	38	7.226		VO2 Max. 1 (ml/kg/min)	38.16	51	12.895
	VO2 Max. 2 (ml/kg/min)	35.21	47	6.538		VO2 Max. 2 (ml/kg/min)	39.76	51	13.341
Greece	Fat 1 (%)	These variables could not be calculated.			Poland	Fat 1 (%)	17.60	74	8.396
	Fat 2 (%)					Fat 2 (%)	17.50	62	8.271
	Fat-Free Mass 1 (kg)	48.10	63	5.910		Fat-Free Mass 1 (kg)	51.01	74	8.065
	Fat-Free Mass 2 (kg)	48.16	63	6.022		Fat-Free Mass 2 (kg)	52.65	62	8.321
	Total Body Water 1 (%)	These variables could not be calculated.				Total Body Water 1 (%)	60.22	74	6.269
	Total Body Water 2 (%)					Total Body Water 2 (%)	60.21	62	6.264
	Body Mass Index 1	21.11	63	2.654		Body Mass Index 1	21.20	74	3.436
	Body Mass Index 2	20.88	63	2.453		Body Mass Index 2	21.74	62	3.346
	VO2 Max. 1 (ml/kg/min)	35.91	63	3.670		VO2 Max. 1 (ml/kg/min)	40.57	70	8.396
	VO2 Max. 2 (ml/kg/min)	38.47	63	3.918		VO2 Max. 2 (ml/kg/min)	40.95	58	8.499
Turkey	Fat 1 (%)	18.35	46	5.876					
	Fat 2 (%)	18.37	46	5.944					
	Fat-Free Mass 1 (kg)	51.19	50	8.926					
	Fat-Free Mass 2 (kg)	50.52	46	8.996					
	Total Body Water 1 (%)	36.25	50	7.673					

	Total Body Water 2 (%)	35.61	50	7.515
	Body Mass Index 1	21.34	50	3.111
	Body Mass Index 2	21.10	50	2.914
	VO2 Max. 1 (ml/kg/min)	33.76	48	5.975
	VO2 Max. 2 (ml/kg/min)	34.21	48	5.670

Table 4: The levels of physical efficiency in the sample according to the ASTRAND-Rhyming test.

Before Intervention									
Country	**Very poor**	**Poor**	**Fair**	**Average**	**Good**	**Very good**	**Excellent**	**cannot classify**	**Total**
Croatia	7	17	8	4	1	0	1	9	47
Greece	9	35	15	4	0	0	0	0	63
Italy	19	7	7	9	6	4	0	0	52
Poland	12	7	22	18	7	4	0	4	74
Turkey	12	16	16	4	0	0	0	2	50
Total	50	108	53	37	14	8	1	15	286
After Intervention									
Country	**Very poor**	**Poor**	**Fair**	**Average**	**Good**	**Very good**	**Excellent**	**Cannot classify**	**Total**
Croatia	4	23	12	6	1	0	1	0	47
Greece	2	19	29	10	3	0	0	0	63
Italy	19	7	7	9	6	4	0	0	52
Poland	9	7	17	15	6	4	0	4	62
Turkey	9	19	17	2	1	0	0	2	50
Total	41	117	53	34	14	8	1	6	274

2.3. Intervention

A sub-sample of the interviewees consisting of 286 pupils out of the 990 participants took part in an intervention including changing their daily mobility mode to school from passive mobility (personal or public motorized transportation) to active mobility (walking or biking) for a specific duration of time. During the intervention, there was a drop-out of 12 participants, so in the end 274 of them completed the intervention, all of whom came from Krakow, Poland. Table 5 summarizes the descriptive statistics of the intervention times at the national level. Only adolescents who used motorized transport modes including household cars and public transportation were invited to change their daily mobility to school. The intervention consisted of changing the motorized mode to biking or walking. The duration of the intervention varied among the participants with a mean value of fewer than 130 days for the overall sample of 286 adolescents.

The Åstrand-Ryhming Test is a cycle test devised by professor Per-Olof Åstrand, a pioneer in modern exercise physiology at the Swedish School of Sport and Health Sciences (GIH) in Stockholm. It is a submaximal cycle ergometer aerobic fitness test, based on the relationship between heart rate during work and the percentage of maximal aerobic capacity. The original test method and nomogram (Åstrand, P.-O. & Ryhming, I., 1954) were later expanded and modified (Åstrand, I., 1960) with a nomogram accounting for men and women of different ages. There are many types of tests based on this nomogram as step tests and treadmill tests. The objective of the 6-minute submaximal cycle test is to monitor the VO_2 max, which is beneficial for athletes as well as for medical rehabilitation as patients do not need to perform at maximum capacity (Wnorowski J., 2002)

Body Composition Analysis is measured on the TANITA Body Composition Analyser which provides estimated values for each measured value of body fat percentage, fat mass, fat-free mass, and total body water by the BIA method.

Bioelecrtical Impendence Analysis (BIA) is a means of measuring body composition by measuring bioelectrical impendence in the body (Janiszewska R., 2013). Fat within the body allows almost no electricity to pass through, while electricity passes rather easily through water, much of which is found in muscles. The degree of difficulty with which electricity passes through a substance is known as the electrical resistance, and the percentage of fat and other body constituents can be inferred from measurements of this resistance (Fomon S. J., Nelson S.E., 2002).

Table 5: The descriptive statistics of the intervention times in the five countries of the sample.

Country	N	Mean	Std. Deviation
Croatia	46	85.78	5.308
Greece	62	121	<0.001
Italy	55	149.95	1.079
Poland	74	153.19	4.898
Turkey	49	124.00	<0.001
Total	286	129.74	23.802

2.4. Analysis Methods

Based on the results of Kolmogorov-Smirnov and Sharipo-Wilk tests of normality, only Fat-Free Mass includes a normal distribution, whereas P-values of less than 0.05 represents a non-normal distribution (Table 6). However, because the frequencies of the subjects of each variable were large enough, applying non-parametric tests was not necessary, and a T-test sufficed the needs of answering the first research question of this study about a possible change in the body composition after the intervention, whereas the null hypothesis was that there is no difference between the values before the intervention compared to after it.

For testing the difference in the physical efficiency after intervention in the school mobility of the overall sample, the Chi-square test of homogeneity was applied, whereas a P-value of less than 0.05 lets reject the null hypothesis that the proportion of the classifications before the intervention was **the same as after the intervention, in other words, the proportion of the physical efficiency changed after the intervention.**

To test the difference in the share of physical efficiency categories among the participants of the overall sample as well as the national-level sub-samples (the second research question), the Chi-square test of homogeneity was applied, where the P-values of less than 0.05 indicated a significant difference in the shares before and after the intervention, in other words, the null hypothesis of similarity of the distribution in the two measurements before and after the intervention was rejected. The two variables in the test were the physical efficiency values consisting of very poor, poor, fair, average, good, very good, and excellent.

Finally, for answering the third research question of this study, the changes in the values of the body composition variables (fat, Fat-Free Mass, Total Body Water, Body Mass Index, VO2 max.) after the intervention were calculated for each participant. Then a multivariate Ordinary Least Square model was generated by regressing the five body composition variables into the number of days each participant took part in the intervention. For checking the model validity, the ANOVA-F test was applied, where P-values of less than 0.05 indicated a valid model. Possible multicollinearity was checked by estimation of the Variance Inflation Factor (VIF) for the explanatory variables, where values of between 1 and 3 indicated no multicollinearity among the independent variables.

Table 6: The results of Kolmogorov-Smirnov and Sharipo-Wilk tests of normality for continuous dependent variables.

Dependent Variable	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	P	Statistic	df	P

Fat 1 (%)	0.111	187	<0.001	0.941	187	<0.001
Fat 2 (%)	0.110	187	<0.001	0.936	187	<0.001
Fat-Free Mass 1 (kg)	0.055	187	0.200	0.993	187	0.455
Fat-Free Mass 2 (kg)	0.047	187	0.200	0.993	187	0.456
Total Body Water 1 (%)	0.073	187	0.017	0.957	187	<0.001
Total Body Water 2 (%)	0.122	187	<0.001	0.947	187	<0.001
Body Mass Index 1	0.112	187	<0.001	0.940	187	<0.001
Body Mass Index 2	0.101	187	<0.001	0.966	187	<0.001
VO2 Max. 1 (ml/kg/min)	0.078	187	0.007	0.974	187	0.002
VO2 Max. 2 (ml/kg/min)	0.085	187	0.002	0.969	187	<0.001

Note: Index 1 refers to before the intervention and index 2 reflects the values measured after the intervention.

3. Findings

3.1. Change in Body composition Values After Intervention

For testing, if the intervention in the daily mobility of the adolescents in all five countries of the study has made any significant difference in their body composition measures including fat, Fat-Free Mass, Total Body Water, Body Mass Index, and VO2 Max., paired T-tests were applied to the overall Europe-wide sample between the values of the variables before and after the intervention. The results have been summarized in Table 7. As seen in the table, after the intervention the percentage of fat significantly increased from 21.12% to 21.14% (P=0.002). The change in the fat of the participants is a significant result, but it is unexpected and difficult to explain. It may have other reasons that are outside the scope of this research (see the discussion section). Fat-Free Mass and the Total Body Water of the participants do not show any significant change after the intervention. However, BMI significantly decreased from 21.68 to 21.62 (P=0.034). In other words, the intervention has successfully and positively affected their body weight. Similarly, their VO2 Max. highly significantly increased from 37.12% to 38.04% (P=<0.001).

The T-tests were repeated at the country level (Table 8). As a result of the school travel intervention, the fat percentage of participants highly significantly decreased from 17.50 to 16.66 in Italy and from 18.35 to 18.37 in Turkey (see Table 3 for means). Fat-Free Mass significantly changed in Greece, Italy, and Turkey (P=0.045, 0.002, and 0.005). This variable highly significantly increased from 51.01 to 52.65 Kg in Poland. Total Body Water significantly decreased from 36.25 to 35.61 percent in Turkey (P=0.006). Although the overall sample had a decrease in BMI after the intervention, the effect was different in Poland compared to Italy and Turkey. The BMI of the polish participants surprisingly significantly increased after the mobility mode change from 21.20 to 21.74 (P=0.020), but in Italy and Turkey, BMI significantly decreased as expected from 22.41 to 21.90 (P=0.012) and from 21.34 to 21.10 (P<0.001) respectively. In Croatia, the VO2 Max. changed highly significantly from a mean of 34.67 to 35.21 ml/kg/min. VO2 Max. highly significantly increased from 35.91 to 38.47 ml/kg/min in Greece and from 38.16 to 39.76 ml/kg/min. in Italy. The increase in VO2 Max. in Poland from 40.57 to 40.95 ml/kg/min was marginally significant (P=0.074).

Table 7: The results of the T-test for finding significant differences in body composition of adolescents after intervention in their school mobility in the overall sample.

Body composition variables compared before and after intervention	Lower	Upper	t	df	2-tailed P
Fat (%)	0.120	0.506	3,201	206	0.002
Fat-Free Mass (kg)	-0.119	0.287	0.818	269	0.414
Total Body Water (%)	-0.205	0.789	1,159	210	0.248
Body Mass Index	0.011	0.275	2,136	272	0.034
VO2 Max. (ml/kg/min)	-1,715	-0.995	-7,410	254	<0.001

Table 8: The results of the T-test for finding the differences in body composition of adolescents after intervention in their school mobility at the national level.

Country	Body composition variables compared before and after intervention	Mean	Std. Deviation	t	df	2-tailed P	Country	Body composition variables compared before and after intervention	Mean	Std. Deviation	t	df	2-tailed P
Croatia	Fat %	0.017	0.577	0.202	46	0.841	Italy	Fat %	0.846	1.176	5.188	51	<0.001
	FFM (Kg)	-0.094	0.345	-1.862	46	0.069		FFM (Kg)	1.353	2.943	3.314	51	0.002
	TBW (%)	-0.083	0.693	-0.821	46	0.416		TBW (%)	0.699	6.994	0.721	51	0.474
	BMI	0.095	0.813	0.800	46	0.428		BMI	0.514	1.404	2.617	50	0.012
	VO2 Max.	-0.529	0.622	-5.251	37	<0.001		VO2 Max.	-1.535	1.912	-5.734	50	<0.001
Greec	FFM (Kg)	-0.063	0.246	-2.050	62	0.045	Poland	Fat %	0.139	2.155	0.507	61	0,614
	BMI	0.230	1.397	1.308	62	0.196		FFM (Kg)	-0.894	1.525	-4.612	61	<0.001
	VO2 Max.	-2.557	1.136	-17.871	62	<0.001		TBW (%)	-0.039	1.584	-0.192	61	0.848
Turkey	Fat %	0.248	0.630	2.670	45	0.011		BMI	-0.292	0.959	-2.397	61	0.020
	FFM (Kg)	0.353	0.818	2.927	45	0.005		VO2 Max.	-1.166	4.842	-1.818	56	0.074
	TBW (%)	0.632	1.571	2.845	49	0.006							
	BMI	0.240	0,403	4.207	49	<0.001							
	VO2 Max.	-0.426	3.042	-0.950	45	0.347							

3.2. Change in Physical Efficiency After Intervention

As explained in the methodology section, for testing the significant changes in the physical efficiency of the participants after changing their school travel modes, the Chi-square test of homogeneity was applied. At the international level, the findings of the overall sample were tested. As seen in Table 9, the P-value of the Pearson Chi-square is less than 0.001, so the null hypothesis that the distribution of the two variables related before and after the intervention (Table 4) are the same can be rejected. In other words, after the intervention, the physical efficiency of the participants was highly significantly improved. The improvement can especially be seen in those participants, who had very poor and poor efficiency in the baseline data collection time. The number of participants with the very poor result decreased from 50 to 41 and the number of poor results increased from 108 to 117 cases. In other words, the intervention had positive effects on the lower ranges of physical efficiency.

At the country level, the same can be seen in Table 10. The physical efficiency of participants in all five countries has a highly significant change after the intervention. The same pattern explained about the overall sample can also be seen in Poland, Poland, and Turkey. The number of adolescents with poor results has been reduced and the same number has been added to the poor results instead (Table 4).

Table 9: The results of the Chi-square test of homogeneity for physical efficiency before and after the intervention in school mobility modes.

Measure	Value	df	2-sided P
Pearson Chi-Square	924.864	49	<0.001
Likelihood Ratio	429.366	49	<0.001

Table 10: The results of the Chi-square test of homogeneity for physical efficiency before and after the intervention in school mobility modes at the national level.

Country	Measure	Value	df	2-sided P
Croatia	Pearson Chi-Square	175.26	30	<0.001

	Likelihood Ratio	84.89		
	N of Valid Cases	47		
Greece	Pearson Chi-Square	103.588	12	<0.001
	Likelihood Ratio	80.200		
	N of Valid Cases	63		
Italy	Pearson Chi-Square	260	25	<0.001
	Likelihood Ratio	172.41		
	N of Valid Cases	52		
Poland	Pearson Chi-Square	109.82	36	<0.001
	Likelihood Ratio	88.47		
	N of Valid Cases	62		
Turkey	Pearson Chi-Square	87.39	20	<0.001
	Likelihood Ratio	68.04		
	N of Valid Cases	50		

3.3. Correlation of the duration of intervention time with body composition measures

An important question to be answered is how much time is needed for the intervention in daily school travel to make a significant change in the body composition factors of adolescents. This was investigated by generating a multivariate Ordinary Least Square (OLS) model with intervention time as the dependent variable. The results show that fat change after the intervention is significantly associated with the intervention time (P=0.002). A one-day increase in the intervention time is correlated with a 0.235 percent (0.00235) increase in the fat of the pupils. In other words, if an adolescent changes his/her school mobility mode from passive to active, his/her body fat can be changed by as much as 63.4%. This finding shows that fat-burning is a body composition factor that is under the effect by time more than other indicators because the other variables in the model do not show any significant correlation with intervention time. The latent meaning behind this finding is that only starting to use active mobility modes will automatically affect the BMI and Vo2 Max. of the adolescents, but for burning fat, the duration of active mobility to school is important.

The explanatory variables of this OLS model have been checked by the Variance Inflation Factor to avoid multicollinearity. The VIF values of all the variables are between one and three, so they do not have multicollinearity with one another. The validity of the model was checked by the ANOVA-F test, the results of which approve the validity of the model (P=0.008). The R^2 of the model is low (0.084) because, in addition to the time of active school mobility, several other factors like lifestyle, nutrition, and inheritance may be in association with body composition.

Of course, fat change per se can be in relation to some other body composition factors, like for example there is a univariate nonlinear correlation between the change in BMI and change in fat, as seen in Fig. 1 (R^2=0.417). Apart from that, an important point is the role of geographies and cultures. As seen in Fig. 2, after an identical intervention in school mobility, the levels of change in body composition variables can be different in European countries.

Table 11: Multivariate OLS model (dependent variable: number of the days of intervention) (R^2=0.084)

Variable	**B**	**Std. Error**	**β**	**t**	**P**	**Collinearity Statistics Tolerance**	**VIF**
Constant	127.186	1.877		67.769	<0.001		
Fat change after the intervention	4.021	1.305	0.235	3.081	0.002	0.894	1.118
Fat-free mass change after the intervention	1.119	0.842	0.099	1.,329	0.186	0.937	1.067
Total body water percentage change after the intervention	0.150	0.444	0.025	0.338	0.736	0.937	1.067
BMI change after the intervention	-0.835	1.295	-0.049	-0.645	0.520	0.890	1. 124

VO2 Max. change after intervention	-0.850	0.579	-0.107	-1.468	0.144	0.982	1.018
ANOVA Test							
Sum of Squares	**df**	**Mean Square**	**F**	**P**			
6827,86	5	1365,57	3.238	0.008			

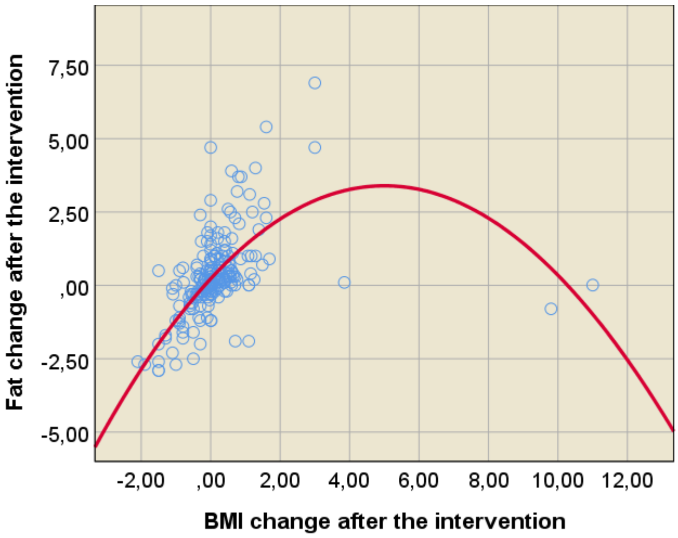

Fig. 1: The cubic correlation between change in the body fat and BMI of adolescents after the intervention (R^2=0.417).

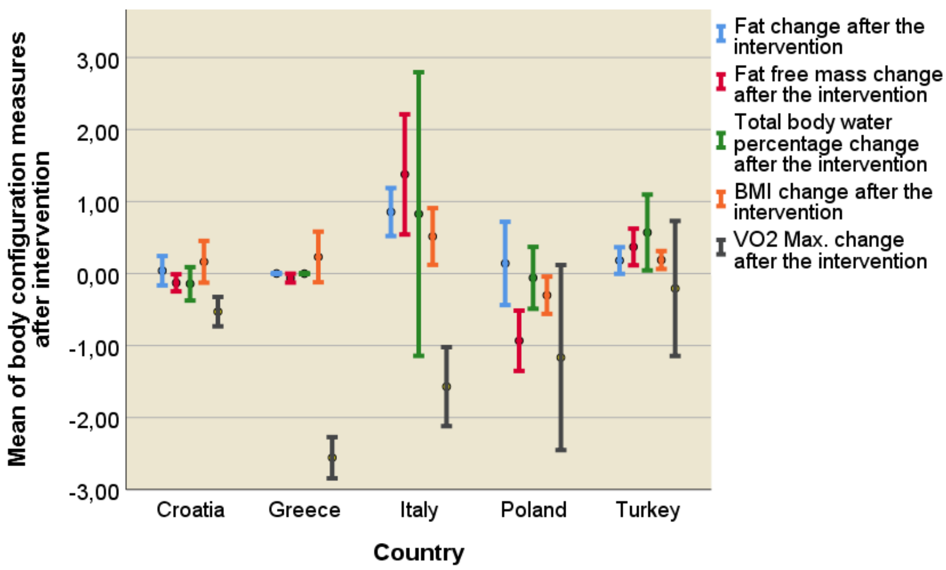

Fig. 2: The mean of changes in body composition measures after the intervention.

4. Discussion

The current study assesses the impacts of the intervention on body composition, physical efficiency, and the relationship between the duration of intervention and body composition. We expected changing from passive to active mode choices affected body composition measures in European cities. According to physical health literature, physical efficiency is correlated with decreases in the percentages of fat, increases in the FFM and VO2 Max, and changes in TBW, and BMI.

The findings of this study show that the percentage of fat has significantly increased from 21.12% to 21.14% after the intervention. This unexpected increase in the percentage of fat probably has others reasons beyond the direct impacts of the intervention. For instance, changing from passive to active mode choices causes adolescents to become activated physically and so, this issue leads to increasing metabolism and eating more among participants during the intervention. Also increasing the level of physical activity is related to increasing hormones among adolescent girls. So, it could be another reason for increasing the percentages of fat among participants in the intervention. Another important issue that should be considered is the amount of fat has changed unexpectedly but the changes in BMI were acceptable due to increasing physical activity. So, it can interpret the participants in the intervention were adolescents between 14 and 18 years old. The process of growing is active in these ages. So, participants have increased in weight and height according to natural growth during the intervention. The last considerable issue is this study only focuses on the impacts of physical activity on body efficiency, the correlates of other crucial factors such as nutrition and diet, perceptual and attitudes of participants, and socioeconomic feature are not studied by this paper.

The findings of this paper on positive shifts of BMI during the intervention are consistent with the results of the study on the effectiveness of interventions in multidisciplinary elementary schools in 2006 (Spiegel and Foulk 2006). However, the intervention in the Spiegel and Foulk study included diet and physical activity. Also, the current study confirms the positive impacts of the intervention on the body composition measures including BMI, Vo2 max, and physical efficiency of participants. These findings are in line with several studies (Plachta-Danielzik et al. 2011; Happell et al. 2012; Manios et al. 1999; Pan et al. 2017; Donnelly et al. 2009).

Atlantis et al. (2006) studied the association between intervention by promoting physical activity and physical health by using the ANVOVA test. According to their study, VO2 Max and BMI remained without changes after intervention. The results of the current study are inverse to the results of Atlantis et al. (2006).

The findings of this study on the increasing percentages of fat after intervention are inconsistent with the results of the study on the influence of physical activity on the reduction of abdominal fat (Kay and Fiatarone Singh 2006). However, age and growth period in adolescents influence the results of the current paper. The reduction between the percentage of body fat and physical activity among elderly adolescents was confirmed by Moore et al. (2003).

Westman et al. (2013) analyzed the influence of physical activity on fat-free mass (FFM) in all ages, during growth, and in later life. Physical activity level was the main determinant of FFM in all ages. The higher physical activity level was correlated with the higher of FFM in all ages. So, the findings of this paper do not show significant changes in the FFM level of participants. So, the results of this paper are the opposite of the above-mentioned paper. However, FFM highly significantly increased from 51.01 to 52.65 Kg in Poland. This variable significantly decreased in Greece, Italy, and Turkey after the intervention.

Lohman et al. (2008) confirmed that physical activity, fat-free mass (FFM), and interaction between FFM and racial group are correlated with cardiorespiratory fitness in adolescent girls. The results of this paper are inconsistent with that study (Lohman et al. (2008)) in all countries except Poland.

Although, there are some unexpected results of body composition at the level of the country and in five European countries, the impacts of intervention are positive in the total physical body efficiency of five European countries and each country separately. It means the physical body health of participants has improved by changing from passive to active mode choices for commuting to schools.

This result is in line with previous studies in physical health and sports literature (Westman et al. 2013; Zaccagni et al. 2014; Amara et al. 2000; Kyle et al. 2006; Westerterp et al. 2021).

Jendrysek et al. (2015) assessed the effectiveness of physical activity on the improving body composition of young people aged 17-18 years in Poland. The findings of this paper agree with the results of that study on Polish young people regarding the positive benefits of physical activity on body composition.

The body composition has improved by shifting to active mobility at the international level, however, there are some unexpected results at the national level. The impacts of cultural, environmental, and economic conditions should be considered.

5. Conclusion

The current study analyzed the effectiveness of changing mode choices from passive to active modes on the body composition of adolescents aged 14-18 years old in five European countries. According to the findings of this study, physical efficiency has improved after intervention in five European countries. The variables of body composition of adolescents show significant changes in all five European countries and each country separately. The percentage of fat has significantly increased after the intervention. Fat-Free Mass and the Total Body Water of the participants do not show any significant change after the intervention. However, BMI significantly decreased. The VO2 Max highly significantly increased from 37.12% to 38.04% after the intervention.

At the country level, Fat-Free Mass decreased in Greece, Italy, and Turkey. FFM highly significantly increased from 51.01 to 52.65 Kg in Poland. Although the changes in BMI were positive by intervention, The BMI of the polish participants surprisingly significantly increased after the mobility mode change.

The associations between the intervention duration and changes in body composition factors were analyzed by employing the OLS model. The findings of the OLS model confirm that fat change after the intervention is significantly associated with the intervention time. This result illustrates that fat-burning is a body composition factor that is related to time more than other indicators because the other variables in the model do not show any significant correlation with intervention time.

This study concentrates on the relationship between body compositions and shifting from passive to active mode choices (physical activity) among adolescents. While. Several factors may influence on body composition of youth including perceptions and attitudes at both individual and household level, socioeconomic status, environmental features, and nutrition and diets. There is a need for more studies that assess the correlations between socioeconomic, perceptual features, nutrition, and body composition as long as physical activity to reach a better understanding of physical body health correlates among different social groups.

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