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Different Variation of Intra-familial Body Mass Index subjected to Covid-19 Lockdown

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ABSTRACT

Background & Aims: Coronavirus disease 2019 (COVID-19) lockdown has represented an inedited model of increased metabolic risk in all age groups, due to negative changes in dietary habits, physical activity, lifestyle. These effects have been generally explored at a population level in distinct age groups. Potential intra-familial, specific effects in adults and children sharing the same socio-economic, cultural level and living habits have been scarcely explored. We aimed to characterize changes of anthropometric indices in parents and in their children during COVID-19 lockdown.

Methods: A cohort of 149 couple parent/children were prospectively enrolled. By a validated questionnaire we explored changes of body mass index (BMI) and individual lifestyle during a 2-month lockdown (May-July 2020).

Results: BMI increased in 70.5% of parents and in 67.8% of their children, with a Δ-BMI of 1.44+0.09 kg/m^2 and 0.36+0.02 Kg/m^2, respectively. BMI increments, however, were only significant in adults and did not correlate in the couple parents/children. Most adults (80.5%) and children (71.4%) did not perform regular physical activity during the lockdown. Direct correlations between dietary changes and BMI variations became evident in children, mainly in terms of a decreased consumption of fresh fruit, pulses, fish, and an increased consumption of cereals, carbohydrates, dairy products, olive oil. In normal weight, overweight and obese children, but not in adults, the increase in sleep hours increased with BMI.

Conclusions: Despite marked lifestyle changes imposed by the COVID-19 lockdown, BMI variations in parents were independent from those observed in their children, pointing to different outcomes in response to the same external, critical event. Thus, primary prevention measures aimed at maintaining a healthy lifestyle require different approaches according to age.

Key words: body mass index - COVID-19 - diet – lockdown – obese – overweight - physical activity - sedentary behavior.

Abbreviations: BMI: body mass index; COVID 19: coronavirus disease 2019; MD: mediterranean diet; NIH: National Institute of Health; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; SDS: standard deviation scores; WHO: World Health Organization.

INTRODUCTION

The pandemic diffusion of the new coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) caused major impacts on health, economy, and social dynamics. During the first wave of the pandemic, besides the direct effect of the coronavirus disease 2019 (COVID-19), staying at home has promoted, in non-infected subjects, sedentary lifestyle, negative psychological consequences, restriction in spending, and accumulation of long-life food with limited use of fresh foods, such as seasonal fruit and vegetables. As a consequence, as shown by a number of previous papers, the lockdown has represented a population-based, inedited model of increased metabolic risk in all age groups, able to affect the health status in a relatively short period [1]. From this point of view, the deleterious combination of the SARS-CoV-2 pandemic with the already ongoing pandemic due to chronic non-communicable diseases such as obesity and metabolic diseases, constituted a condition for a syndemic [2].

The excessive consumption of foods with a high glycemic index, such as those rich in simple carbohydrates (storable

for a longer time), and the limitation of physical activity have been promoted the accumulation of fat mass and metabolic consequences [3], with an increased risk of the most severe COVID-19 complications [4].

Previous studies reported negative metabolic outcomes of the lockdown both in adults and in children. These effects have been linked with altered eating behavior and lifestyle [5-8], with a significant reduction in physical activity [9, 10], and with an impairment of psychological health [11, 12].

However, these studies were based on self-reported questionnaires, which may lead to misreporting of data. Furthermore, the reported effects on body size variations have been generally explored, at a population level, in separate age groups, and the existence of possible intra-familial, distinct outcomes in adults and children sharing the same critical event and living environment have been scarcely explored.

From this point of view, in particular, besides genetic factors, the weight status of children may be largely affected by parents through imposed variations in diet and/or lifestyle, and the risk of childhood obesity can significantly increase if one or both of a child's parents are overweight/obese [13].

We aimed to extend the previous observations concerning anthropometric data at the intra-familial level. In particular, we prospectively characterized the variations in lifestyle habits and related outcomes over a two months COVID-19 lockdown period, exploring both parents and their children.

METHODS

We designed an observational study using a validated questionnaire [1] to profile adults (parents) and their children living in Apulia region (Southern Italy) during the lockdown imposed in the first wave of the pandemic. Overall, 149 parents and 149 children/adolescents were recruited. The study period was 2 months (from 15 May 2020 to 15 July 2020). Enrolled in the protocol were accompanying parents and children seen at the outpatient clinics of the Pediatric Units in collaboration with the staff of the Unit of Internal Medicine. Participation in the study was voluntary. Children entered the study after parental written informed consent. Adults enrolled in the study also provided their informed consent. The study protocol was approved by the Local Ethical Committee. All the procedures were performed in agreement with the guidelines of the Helsinki Declaration on Human Experimentation, and according to the restrictions for accessing hospital facilities, due to COVID-19 ongoing restrictions.

Weight and height before the lockdown were obtained by the measurements made by the family doctors or pediatrician. The anthropometric indices [height, weight, body mass index-standard deviation score (BMI-SDS)] two months after the stop of closing period were evaluated by internists (adults) or pediatric endocrinologists (children). Children were defined normal weight, overweight and obese according to World Health Organization (WHO) criteria [14]. In adults, the BMI index (Quetelet's index) was calculated from the weight and square of the height according to the following formula: BMI = body weight (in kg) ÷ height (in meters) squared. Subjects were therefore stratified according to the National Institute of Health (NIH) and WHO as underweight (BMI <18.5 kg/m^2), normal weight (BMI ≥18.5 to 24.9 kg/m^2), overweight (BMI ≥25.0 to 29.9 kg/m^2), or obese (BMI ≥30 kg/m^2) [15].

The questionnaire was assistant-administered by a pediatrician to children/adolescents. The staff of internal medicine supervised the completion of the questionnaire of the accompanying parent, either the mother or father.

Subjects provided data in relation to the following variables: age, gender, education, previous conditions, number of siblings. Additional information included level of physical activity, screen exposure, sleep time, and eating habits and were part of the proposed questionnaire which included 41 questions divided into four different sections: 1) personal information (7 questions): age, gender, nationality, education, and current employment (especially if they had the possibility to work from home, also called "smart working"), home location (country or city), number of family members living at home; 2) anthropometrics information (2 questions): weight and height before the pandemic and after the lockdown; 3) information on dietary habits: a. food frequency: number of meals/days before, during and after the lockdown; b. structured questionnaire packet (11 questions: daily consumption, before, during and after the lockdown, of fruit, vegetables, cereals, legumes, sugars, salt, packaged sweets and baked products, sweet beverages, salted snacks and dressing sauces, water); 4) Information on lifestyle habits: hours of sleep and physical activity (hours per week/intensity).

For children, the inclusion criteria were: (i) being able to answer the study questionnaire; (ii) age between 5 and 18 years; (iii) absence of ongoing therapies.

Data are expressed as mean and standard error (SE) for continuous variables. Frequency and percentages were used for categorical variables. The Chi-square test (proportions), the Mann-Whitney U test (unpaired data), the Wilcoxon Signed-Rank Test (paired data), or the Kruskal-Wallis Multiple-Comparison Z-Value test (inter-group differences) were employed to evaluate intra- or inter-group differences. The Spearman correlation coefficient estimated the correlations.

RESULTS

The general characteristics of the study population are detailed in Table I.

Among parents, more than half of enrolled subjects showed a normal weight before the lockdown. Normal weight and obese subjects were more frequently females. Conversely, the percentage of overweight subjects was slightly higher in males: 10 out of the 26 subjects (38.5%) vs 34 out of the 123 subjects (27.6%) (p=0.0001).

Most children, 85 out of the 149 subjects (57.0%) were in the age group 10-15 years, and 88 (59%) showed a normal weight before the lockdown. The obesity rate was higher in females (19 out of the 73 subjects, 26%), than in males (11 out of the 76 subjects, 14.5%).

Body mass index increased during the lockdown in 105 out of the 149 adult subjects (70.5%) and 101 out of the 149 children (67.8%), with a Δ-BMI 1.44+0.09 kg/m^2 and 0.36+0.02 kg/m^2, respectively (Table IIA). Body mass index decreased during the lockdown in a minority of adults (15 out the 149 subjects, 10.1%) and children (18 out of the 149 subjects, 12.1%) (Table IIA). The Δ-BMI was higher in children with increased, than in

Table I. General characteristics of the study population

Adults	All	Females	Males	p*
Number (%)	149	123 (82.6)	26 (17.4)	0.01
Age (years)	44.1±0.5	43.4±0.5	47.6±1.2	0.01
BMI (Kg/m^2)		27.4±2.1	26.3±0.8	0.110
Normal weight, N (%) (BMI ≥18.5 to 24.9 kg/m^2)	84 (56.4)	71 (57.7)	13 (50)	0.0001
Overweight, N (%) (BMI ≥25.0 to 29.9 kg/m^2)	44 (29.5)	34 (27.6)	10 (38.5)	0.0001
Obese, N (%) (BMI ≥30 kg/m^2)	21 (14.1)	18 (14.6)	3 (11.5)	0.0001
Children		Females	Males	p*
Number (%)	149	73 (49%)	76 (51%)	0.584
Age (years)	12.0 ± 0.3	11.5 ± 0.3	12.0 ± 0.4	0.055
Age class, n. (%)				
5-9 years	40 (26.8)	22 (30.1)	18 (23.7)	0.051
10-15 years	85 (57)	44 (60.3)	41 (53.9)	0.233
16-18 years	24 (16.1)	7 (9.6)	17 (22.4)	0.009
BMI-SDS				
Normal weight, N (%) BMI-SDS <85th centile	88 (59)	38 (52.1)	50 (65.8)	0.093
Overweight, N (%) BMI-SDS >85th centile	31 (20.8)	16 (21.9)	15 (19.7)	0.065
Obese, N (%) >97th centile	30 (20.1)	19 (26)	11 (14.5)	0.03

*Between gender; data expressed as mean ± standard error or as rate, as appropriate. BMI: body mass index. SDS: standard deviation scores. Difference evaluated by Chi-square test or by Mann-Whitney U test, as appropriate.

those with decreased or unchanged BMI, and the same trend was evident in adults.

When compared with values measured before the lockdown, significant post-lockdown BMI variations were only evident in adults, irrespective of their prior classification (i.e., normal weight, overweight, obese) (Table IIB). Although a trend towards an increased BMI-SDS was evident in all subgroups of children, the variations before and after 2 months of lockdown were not significant.

Table III shows the effects of the lockdown on BMI variations according to gender, age class, and level of physical activity.

Table II. **A)** BMI change (Δ-BMI) in a cohort of parents (adults) and their children during the lockdown

	Decreased BMI n, (%)	Unchanged BMI n, (%)	Increased BMI n, (%)
Adults			
N (%)	15 (10.1%)	29 (19.5%)	105 (70.5%)
Age (yrs)	42.9±1.8	43.9±1.2	44.4±0.6
Δ-BMI (Kg/m^2)	-1.36±0.2	0.02±0.2#	1.44±0.09#§
Children			
N (%)	18 (12.1%)	30 (20.1%)	101 (67.8%)
Age (yrs)	14.3±0.6	12.5±0.7	11.4±0.3
Δ-BMI-SDS	-0.23±0.04	0.00±0.00	0.36±0.02#§

Data expressed as mean ± standard error or as rate, as appropriate. BMI: body mass index. *#vs decreased BMI-SDS; §vs unchanged BMI-SDS (Kruskal-Wallis Multiple-Comparison Z-Value test).

Tabel II. **B)** BMI change before and after the lockdown

	Before lockdown	After lockdown	p
Adults			
BMI (Kg/m^2)			
All	25.4±1.8	27.3±1.4	0.00001
Normal weight	22.5±0.2	25.6±2.5	0.00001
Overweight	26.7±0.3	27.1±0.2	0.00009
Obese	34.4±0.8	34.8±0.8	0.01
Children			
BMI-SDS			
All	0.8±0.10	1.05±0.10	0.136
Normal weight	0.07±0.81	0.11±0.09	0.859
Overweight	1.45±0.05	1.50±0.05	0.562
Obese	2.44±0.14	2.54±0.13	0.384

Data expressed as mean ± standard error. BMI: body mass index. SDS: standard deviation scores. Difference tested by Wilcoxon test.

In children, the BMI-SDS variation was significantly lower in the age class 16-18 years, than in children aged 5-9 or 10-15 years. Most adults (120 out of the 149 subjects, 80.5%) and children (105 out of the 149 subjects, 71.4%) did not perform regular physical activity during the lockdown. Among adults, subjects performing regular physical activity had a lower weight gain as compared with sedentary subjects.

Conversely, in children, the Δ-BMI-SDS recorded during the lockdown was similar in those with and without regular

Table III. Effect of lockdown on BMI variation according to gender, age, body mass index, and physical activity

	Number (%)	Δ-BMI	p within groups
ADULTS	149	0.9±0.1	
Male	26 (17.4)	0.91±0.1	0.66
Female	123 (82.6)	0.8±0.2	
BMI group			
Normal weight	84 (56.4)	0.8±0.1	0.43
Overweight	44 (29.5)	1.1±0.2	
Obese	21 (14.1)	0.7±0.3	
Physical activity during the lockdown1			
No	118 (79.2)	0.99±0.1	0.02
Yes	31 (20.4)	0.4±0.2	
Time spent for physical activity[1]			
None	120 (80.5)	0.9±0.1	1.56
10 minutes- 2.5 hrs/week	13 (8.8)	0.5±0.3	
>2.5 hrs/week	16 (10.9)	0.5±0.3	
	Number (%)	**Δ-BMI-SDS**	
CHILDREN	149	0.22±0.02	
Male	76 (51)	0.21±0.03	0.527
Female	73 (49)	0.23±0.04	
Age class			
5-9 years	40 (26.8)	0.35±0.05*	0.001
10-15 years	85 (57)	0.20±0.03*	
16-18 years	24 (16.1)	0.06±0.05*	
BMI group			
Normal weight	88 (59.1)	0.22±0.04	0.869
Overweight	31 (20.8)	0.23±0.05	
Obese	30 (20.1)	0.18±0.04	
Physical activity during the lockdown[1]			
No	105 (71.4)	0.22±0.03	0.095
Yes	42 (28.6)	0.22±0.05	
Time spent for physical activity			
None	107 (72.8)	0.22±0.03	0.029
10 minutes- 2.5 hrs/week	18 (12.2)	0.09±0.28	
>2.5hrs/week	22 (15)	0.28±0.35	

Data expressed as mean ± standard error or as rate, as appropriate. Difference was evaluated by Mann-Whitney U test or by Kruskal-Wallis Multiple-Comparison Z-Value test, as appropriate.

physical activity. In both adults and children, the BMI variations recorded during the lockdown were independent from the time spent for physical activity (i.e., none, 10 minutes to 2.5 hours/week, more than 2.5 hours/week). In this respect, however, a trend towards a more marked weight gain in sedentary subjects was only present in adults.

During the lockdown, small changes in children's eating habits were recorded. As shown in Table IV, the consumption of fresh fruit, pulses and fish consumption decreased, while an increase in the consumption of cereals, carbohydrates, dairy products, and olive oil was observed. A slight increase in the consumption of vegetables was also present. Table IV shows changes in the eating habits of adults during the lockdown, with an increase in the consumption and pulses of cereals and derived products, meat, dairy products and olive oil, and a decreased consumption of fresh fruit and vegetables.

When the couple parent-child was considered, the weight variations recorded during the lockdown in parents and in their children were not correlated. Similar findings were also present when subjects were divided according to previous BMI (i.e., normal weight, overweight or obese). In children, but not in adults, direct correlations were evident between dietary changes and BMI variations.

As shown in Table V, the increased BMI observed in children with normal BMI-SDS before the lockdown was

Table IV. Assessment adherence to Mediterranean Diet

	BEFORE LOCKDOWN			DURING LOCKDOWN			AFTER LOCKDOWN		
ADULTS, N (%)									
Fruit or fruit juice	<1/day	1-1.5/day	>1.5/day	<1/day	1-1.5/day	>1.5/day	<1/day	1-1.5/day	>1.5/day
	54 (36.2)	47 (31.5)	48 (32.2)	50 (33.6)	52 (34.9)	47 (31.5)	53 (35.6)	50 (33.6)	46 (30.8)
Fresh or cooked vegetables	<1/day	1-2.5/day	>2.5/day	<1/day	1-2.5/day	>2.5/day	<1/day	1/day	>2.5/day
	60 (40.3)	64 (43)	25 (16.7)	62 (41.6)	62 (41.6)	25 (16.8)	59 (39.6)	65 (43.6)	25 (16.8)
Pulses	<1/week	1-2/week	>2/week	<1/week	>1/week	>2/week	<1/week	1-2/week	>2/week
	60 (40.3)	62 (41.6)	27 (18.1)	60 (40.3)	52 (34.9)	37 (24.8)	62 (41.6)	60 (40.3)	27 (18.1)
Cereal or cereal products (pasta, rice)	<1/day	1-2/day	>2/day	<1/day	1-2/day	>2/day	<1/day	1-2/day	>2/day
	68 (45.6)	48 (32.2)	33 (22.1)	50 (33.6)	32 (21.4)	67 (45)	67 (45)	47 (31.5)	35 (23.5)
Regular fish consumption	<1/week	1-2.5/week	>2.5/week	<1/week	1-2.5/week	>2.5/week	<1/week	1-2.5/week	>2.5/week
	67 (45)	67 (45)	15 (10)	69 (46.3)	59 (39.6)	21 (14.1)	67 (45)	64 (43)	18 (12)
Meat	<1/day	1-1.5/day	>1.5/day	<1/day	1-1.5/day	>1.5/day	<1/day	1-1.5/day	>1.5/day
	68 (45.6)	51 (34.2)	30 (20.2)	60 (40.3)	49 (32.9)	40 (26.8)	68 (45.6)	47 (31.5)	34 (22.9)
Dairy products	<1/day	1-1.5/day	>1.5/day	<1/day	1-1.5/day	>1.5/day	<1/day	1-1.5/ day	>1.5/day
	82 (55.1)	47 (31.5)	20 (13.4)	68 (45.6)	56 (37.6)	25 (16.8)	77 (51.7)	51 (34.2)	21 (14.1)
Use of olive oil	Sometimes	Often	Always	Sometimes	Often	Always	Sometimes	Often	Always
	18 (12.1)	41 (27.5)	90 (60.4)	17 (11.4)	40 (26.8)	92 (61.8)	18 (12.1)	41 (27.5)	90 (60.4)
	BEFORE LOCKDOWN			DURING LOCKDOWN			AFTER LOCKDOWN		
CHILDREN, N (%)									
Fruit or fruit juice	<1/day	1/day	>1/day	<1/day	1/day	>1/day	<1/day	1/day	>1/day
	82 (54.7)	36 (24)	32 (21.3)	82 (54.7)	37 (24.7)	31 (20.6)	84 (56)	41 (27.3)	25 (16.7)
Fresh or cooked vegetables	<1/day	1/day	>1/day	<1/day	1/day	>1/day	<1/day	1/day	>1/day
	88 (58.7)	6 (4)	56 (37.3)	87 (58)	5 (3.3)	58 (38.7)	88 (58.7)	6 (4)	56 (37.3)
Pulses	<1/week	>1/week		<1/week	>1/week		<1/week	>1/week	
	75 (50)	75 (50)		78 (52)	72 (48)		75 (50)	75 (50)	
Meat	<1/day	>1/day		<1/day	>1/day		<1/day	>1/day	
	72 (48)	78 (52)		68 (45.3)	82 (54.7%)		75 (50)	75 (50)	
Cereal or cereal products (pasta, rice)	<1/day	>1/day		<1/day	>1/day		<1/day	>1/day	
	69 (46)	81 (54)		59 (39.3)	91 (60.7)		67 (44.7)	83 (55.3)	
Regular fish consumption	<2-3/week	>2-3/week		<2-3/week	>2-3/week		<2-3/week	>2-3/week	
	80 (53.3)	70 (46.7)		83 (55.3)	67 (44.7)		85 (56.7)	65 (43.3)	
Dairy products	<1/day	>1/day		<1/day	>1/day		<1/day	>1/day	
	72 (48)	78 (52)		67 (44.7)	83 (55.3)		85 (56.7)	65 (43.3)	
Use of olive oil	No	Yes		No	Yes		No	Yes	
	40 (26.7)	110 (73.3)		38 (25.3)	112 (74.7)		39 (26)	111 (74)	
Total	Low Adherence (<3)	Moderate Adherence (4-7)	High Adherence (>8)	Low Adherence (<3)	Moderate Adherence (4-7)	High Adherence (>8)	Low Adherence (<3)	Moderate Adherence (4-7)	High Adherence (>8)
	59 (39.3)	89 (59.3)	2 (1.4)	56 (37.3)	90 (60)	4 (2.7%)	61 (40.7)	87 (58)	2 (1.3)

For adults adapted from Medi Lite Questionnaire, and for children adapted from KidMed Questionnaire.

likely associated with reduced consumption of fruit (p=0.003), vegetables (p=0.0001), cereals (p=0.0001) and olive oil (p=0.0001), and with increased consumption of meat (p=0.024) and dairy products (p=0.024). The reduced intake of fruit (p=0.02), vegetables (p=0.0001), and cereals (p=0.0001) and, more generally, a lower adherence to the Mediterranean diet (MD) (p=0.028) led to weight gain even in children remaining in the „normal weight" group after the lockdown.

In overweight children, the BMI increase was related with the decreased consumption of vegetables (p=0.004) and dairy products (p=0.0001). In obese children, the BMI increase was related with the reduced consumption of dairy products (p=0.001), pulses (p=0.003) and cereals (p=0.001), and with the increased consumption of meat (p=0.041) and fish (P=0.004).

In terms of sleeping time, no difference was found before and during the lockdown in most adults (n=87, 58.4%). An increase in hours of sleep was observed in 45 adults (30.2%), and a reduction in 17 (11.4%). In 58 out of 149 children (39%) no difference in hours of sleep was present before and during the lockdown. The sleeping time increased in 70 children

Table V. Correlation between BMI-SDS groups and eating habits in children

	Score Fruits	Vegetable score	Pulse score	Cereal score	Fish score	Meat score	Dairy product score	Oil score	KidMed score	Sleeping hours
Normal BMI-SDS before lockdown	r= -0.088 p=0.003	r= -0.284 p=0.0001	-	r= -0.134 p=0.0001	-	r= 0.068 p=0.024	r= 0.111 p=0.024	r= -0.115 p=0.0001	-	r= 0.094 p=0.002
Overweight BMI-SDS before lockdown	-	r= -0.154 p=0.004	-	-	-	-	r= -0.402 p=0.0001	-	-	r= 0.162 p=0.002
Obese BMI-SDS before lockdown	-	-	r= -0.166 p=0.003	r= -0.187 p=0.001	r= 0.111 p=0.004	r= 0.113 p=0.041	r= -0.184 p=0.001	-	-	r= 0.188 p=0.001
Normal BMI-SDS after lockdown	r= -0.076 p=0.02	r= -0.201 p=0.0001	r= -0.154 p=0.0001	r= -0.130 p=0.0001	r= 0.108 p=0.001	-	-	-	r= -0.070 p=0.028	-
Overweight BMI-SDS after lockdown	r= 0.123 p=0.01	-	r= -0.274 p=0.0001	-	r= 0.319 p=0.0001	r= 0.191 p=0.0001	r= -0.223 p=0.0001	-	-	-
Obese BMI-SDS after lockdown	r= -0.231 p=0.0001	-	-	-	-	-	r= -0.165 p=0.001	r= 0.140 p=0.006	r= -0.127 p=0.013	r= 0.156 p=0.002

(47%) and decreased in 21 (14%). In adults, no statistically significant correlation was found with the increase in sleep hours, irrespective of the BMI class before the lockdown. In normal weight (p=0.002), overweight (p=0.002) and obese (p=0.001) children, the increase in sleep hours was directly related with the BMI increases.

DISCUSSION

In the present study we had the chance to dissect the intra-familial impact of two month of lockdown due to COVID-19 pandemic on BMI in a large cohort of non-infected parents and in their children/adolescents. Data showed differential effects in two distinct age-groups exposed to the same critical event and sharing the same living environment. In particular, BMI increase observed in adults was independent from that observed in children, underlying the presence of different, age-related effects of external factors on the individual outcome.

In this cohort, the BMI variation was independent from gender and from previous BMI and, in children, less pronounced changes were noticed in the age group 16-18 years, than in subjects aged 5-15 years.

Although some changes in eating habits were reported, the overall adherence to MD during the lockdown was similar as that observed before the lockdown, suggesting a minor role for changes in dietary habits in the promotion of BMI variations. Of note, low adherence to MD in children is considered a major risk factor for children overweight/obesity [16, 17].

The use of dietary regimen rich in anti-inflammatory nutrients, such as polyphenols, included in MD represents a favorable preventive and therapeutic approach for obesity [18]. Furthermore, an unhealthy diet and lifestyle may cause greater exposure to pathogens and a worse immune response, both innate and adaptive [5]. Improvements in parents' lifestyle are equally needed, since it affects children's weight, blood pressure and health status [19, 20].

Our study demonstrated that both adults and children had a reduced physical activity during the pandemic, preferring sedentary activities. These data agree with those reported by some [21-23], but not all previous studies. In this respect, a study conducted in Italy in a cohort of adults reported an increase in physical activity during the lockdown, because of more free time [5]. A study in a USA cohort showed that, in children, the reduced physical activity occurred from the early periods of lockdown, probably due to the impossibility to perform physical activity at school [8].

Sedentary lifestyle is reported as a risk factor for obesity both in adults and children. In the present series, this finding was confirmed in adults, in whom a link between weight gain and a decreased physical activity was observed. However, this was not the case of children, in whom the short-term BMI variations were not related with physical activity, nor with the time spent for physical activity. Thus, the possibility exists that a longer duration or a higher intensity of physical activity are required to prevent a BMI increment in children, as compared with adults.

In both adults and children, moderate changes in eating habits and an increase in sleep hours were found in all three weight classes (i.e., normal weight, overweight and obese). This last finding is in contrast with results from a French study [24] reporting a reduced amount of the hours of sleep in adults. A decrease in sleeping time was expected, due to the reduced physical activity and the increased screen exposure [25]. Our results, however, did not confirm this hypothesis, probably due to the possibility of a later wake up linked with smart working and remote school lessons.

In our cohort of adults, dietary changes were not related with BMI variations. This finding is not in line with results from a Polish study suggesting that a dietary „unhealthy pattern" was associated with weight gain in adults [7].

Thus, the BMI variations observed in our series of adults seem to be mainly linked with the low level of physical activity and the increase in sleep hours [10]. As for children, no statistically significant correlation was found between physical activity and BMI-SDS. The most significant findings are related with dietary habits and hours of sleep. Most of the similar studies report in both adults [5] and children [10] a reduction in the consumption of fruit and vegetables, and an increase in carbohydrates and home baked dishes, probably due to the difficulties in finding fresh food daily during pandemic and, at the same time, the struggle in reconciling home working and children managing in the very first period of restrictions.

The most interesting finding of our study is that, in children, qualitative alterations of dietary habits (i.e., lower adherence to MD) have a relevant impact on BMI, as well as the increased hours of sleep. This occurs regardless of the starting BMI class. In fact, even in children who were in a condition of normal weight before lockdown, incorrect dietary habits were associated with weight gain.

CONCLUSIONS

Restrictions caused by the lockdown during the first wave of the COVID-19 pandemic pave the way to major changes in dietary habits and lifestyle, with a worsened metabolic risk in all ages. However, we show that adults and children sharing the same living environment, cultural level and socio-economic status show different BMI variations in response to the same external, critical event. In particular, in adults the weight gain can be mainly explained by reduced physical activity and increased hours of sleep, while in children was mainly secondary to qualitative changes of dietary habits. Social distancing is still one of the most effective preventive measures for COVID-19 pandemic. On the other hand, the increased risk of metabolic abnormalities suggests the need for primary prevention measures aimed at maintaining a healthy lifestyle even during periods of home confinement. These measures, however, should be modulated to involve different targets according to age.

Conflicts of interest: None to declare.

Authors' contribution: M.F.F. and P.P. designed the research study. All authors were involved in the data acquisition. V.C, A.D.C, L.B., F.U., M.C., G.B., P.G. and F.C. analyzed the data. M.F.F. and P.P. drafted the manuscript. All authors critically revised the manuscript, approved the final version to be published, and agree to be accountable for all aspects of the work.

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