Consequences of COVID-19 pandemic on weight gain and physical activity: a prospective cohort study from Italy

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Abstract

Introduction. It is crucial to monitor changes in body weight and physical activity (PA) to understand if short-term effects of COVID-19 pandemic have had implications over time.

Methods. This longitudinal study is based on data from 4,831 Italians aged 18-74 years interviewed during the first phase of COVID-19 pandemic (April-May 2020) and two years later (February-March 2022). Changes in body weight and PA were assessed through multivariable analyses in association with socio-demographic and psychological characteristics.

Results. Over the two years, 17.4% reported a weight gain of at least 5 kg and 32.8% a decreased PA by at least 4 hours per week. Weight gain and decreased PA were more frequent in participants from the less wealthy areas, with lower educational level and those who reported a worsening in mental health.

Conclusions. After two years from the start of the pandemic, in Italy we observed a trend toward a renormalization of body weight and PA. The segments of the population mostly affected by the pandemic are subjects with more disadvantaged socio-economic status and with an impaired mental health.

Key words
• COVID-19
• coronavirus
• lockdown
• obesity
• physical activity
• pandemic

INTRODUCTION

With the rapid spread of the coronavirus disease (COVID-19) in early 2020, due to the absence of any effective drugs or vaccines at that time, governments of more than 100 countries worldwide introduced non-medical countermeasures to limit the spread of the virus. Italy was the first European country to register an important growth in infections in early 2020 [1] and to impose a restrictive national lockdown [2] in March, 2020. The measures included the closure of all non-essential activities, including schools/university, sport activities, shops, and factories [3]. People were forced to stay at home and were only allowed to go out for grocery shopping or for health reasons. All working activities were turned into home-based working or were suspended, apart from few essential activities, including health workers and food supply and sales.

The COVID-19 lockdown caused significant disruption in people's everyday lifestyle. Many studies have already reported a detrimental effect of the confinement period in Italy on mental health [4-6] and addictive behaviours [7-10]. Some studies have already shown that confinement had a relevant impact on people dietary habits and physical activity (PA) [3, 11]. Results from a recent meta-analysis on multiple countries, showed that body weight significantly increased in the general population, with a weight mean difference of +1.57 kg (95% confidence interval, CI 1.01-2.14) after the first COVID-19 lockdown [12]. Another systematic review on PA, based on 23 Italian studies, showed a significant

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reduction in PA during the lockdown compared to before the pandemic [13].

These tendencies are particularly worrying since, although Italy is among the countries with lowest adult obesity prevalence (less than 8%) compared to the rest of Europe (more than 20% in most of the countries) [14], the prevalence of obesity and physical inactivity are increasing steadily worldwide and the COVID-19 pandemic may have boosted these trends. Previously published studies have shown that lifestyle changes, overeating and increasing sedentarism during the CO-VID-19 lockdown period might have led to an increase in obesity prevalence, and have proposed a new definition of "covibesity" pandemic [15].

Estimates on childhood obesity prevalence are likewise alarming, since Italy ranges among the countries with highest prevalence (around 16%) compared to the rest of Europe (approximately 12%) [16], with large disparities by socio-economic status and geographic area [17].

It is therefore crucial to monitor changes in weight and PA habits and their correlates on a long-time period to understand if short-term effects of COVID-19 pandemic have had implications over time, this to target subgroups of the population that remained mostly hit by the pandemic period. Therefore, the aim of this study is to evaluate the long-term effects of the CO-VID-19 pandemic on weight gain and PA in a large sample of the Italian adult population.

MATERIALS AND METHODS

This longitudinal study is based on data from the "Lost in Italy" survey [2] and the "Lost in Toscana" survey. The fieldwork was conducted by Doxa, the Italian branch of the Worldwide Independent Network/Gallup International Association, and coordinated by Mario Negri Institute, the Oncologic Network, Prevention and Research Institute (Istituto per lo Studio e la Prevenzione Oncologica, ISPRO), and other Italian universities and research institutes.

The baseline sample, representative of the Italian population aged between 18 and 74 years in terms of age, sex, socio-economic characteristics and geographic area, was extracted from the Doxa online panel, consisting of more than 140,000 adults from all the Italian regions, including about 40,000 active subjects. Overall, 6,003 subjects took part to a first interview (baseline interview) between April 27th and May 3rd, 2020. All participants of the baseline interview accepted to be re-contacted for a follow-up interview, and 4,831 took part to the second interview between February 24 and March 21, 2022.

The study protocol of the "Lost in Italy" study was approved by the ethics committee (EC) of Mario Negri Institute (EC of Istituto Besta, file number: 71-73, April 2020), and that of the "Lost in Toscana" survey was approved by the EC of ISPRO (Comitato Etico Regionale per la Sperimentazione Clinica della Toscana – sezione Area Vasta Centro, file number: CEAVC 19834, April 2021). All participants provided their informed consent to participate to the study. The study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Outcome variables

In the baseline and follow-up interview, individuals were asked to report their height and weight. Body mass index (BMI) was computed as the ratio between self-reported weight (kg) and height (m^2), and was categorized according to the standard classification by the WHO [18] i.e., underweight (BMI <18.5 kg/m^2), normal weight (BMI between 18.5 and 24.9 kg/m^2), overweight (BMI between 25.0 and 29.9 kg/m^2), and obesity (BMI ≥30.0 kg/m^2). Obesity was then categorized in obesity class one (BMI between 30.0 and 34.9 kg/m^2), obesity class two (BMI between 35.0 and 39.9 kg/m^2) and obesity class three (BMI ≥40.0 kg/m^2).

Participants provided also information on the average number of hours per week (h/w) of PA (sports and recreation, bicycle commuting) they practiced.

In the baseline survey, in order to evaluate any change in BMI and PA occurred during COVID-19 lockdown, weight and average number of h/w of PA were reported twice, referring to the moment of the interview (reference time: April-May 2020) and before the start of the pandemic (reference time: early February 2020).

Independent variables

The baseline and follow-up questionnaires collected information on socio-demographic characteristics such as age, sex and level of education, marital status, if they had any children, the crowding of their house and characteristics of the area of residence, including geographic area (i.e., northern, central and southern Italy) and municipality size.

The baseline interview also investigated changes in participants' sexual activity during the lockdown.

A specific section of the questionnaires was focused on selected addictive behaviours. Participants reported their smoking status, if they used cannabis, if they were at risk of alcohol use disorder (according to AUDIT-C scale [19]) and their gambling habits.

Another section was on mental health outcomes, such as quality of life (assessed with the visual analogue scale, VAS [20]), quality and quantity of sleep (using 2 items of the Pittsburgh Sleep Quality Index, PSQI [21]), anxiety (generalized anxiety disorder, GAD-2 scale [22]) and depressive symptoms (patient health questionnaire, PHQ-2 [23]).

In the baseline survey, all the questions on addictive behaviours and mental health outcomes were asked twice referring to two different time periods (before the onset of the pandemic and during the lockdown).

Statistical analysis

Weight and BMI mean, and the distributions of BMI and physical activity levels were assessed in the three different time points (February 2020, April 2020 and March 2022). We used unconditional multiple logistic regression models to estimate odds ratios (OR), and corresponding 95% confidence intervals (CI), of increasing weight by at least 5 kg and of decreasing PA by at least four h/w at follow-up, compared to before the onset of the pandemic (i.e., March 2022 *vs* February 2020). All the models were adjusted for selected socio-demographic variables, i.e., sex, age, level of edu-

cation and geographic area. All statistical analyses were performed using the software SAS, version 9.4 (Cary, North Carolina, USA).

RESULTS

Table 1 and *Supplementary Table 1 (available online)* show the distribution of weight, BMI and PA before the onset of the COVID-19 pandemic, during the COVID-19 lockdown and at follow-up, and their changes in the three different periods, overall and by sex. In general, participants' average weight increased approximately by 1.0 kg during the COVID-19 lockdown (from 72.9 kg to 73.8 kg). After two years, the average weight was 0.5 kg more compared to before the pandemic (from 72.9 kg to 73.4 kg).

The prevalence of overweight participants increased by 3.9% during the COVID-19 lockdown (from 30.9% to 32.1%) and by 6.5% after two years from the start of the pandemic (from 30.9% to 32.9%). Obesity prevalence increased by 17.7% during the lockdown (from 12.4% to 14.6%) and was 8.1% more at follow-up (from 12.4% to 13.4%), compared to before the pandemic. The increase in obesity prevalence during the lockdown and two years later was +20.5% and +8.7%, respectively, among men, and +15.8% and +7.5%, respectively, among women.

Overall, the average h/w of PA approximately halved during the COVID-19 lockdown (from 4.2 h/w to 2.3

h/w) returning to 4.1 h/w after two years. The decrease in the proportion of participants practicing physical activity 4 h/w or more during the lockdown and two years later was -51.1% and -12.1% overall, and respectively, -55.4% and -10.9% among men, and -45.1% and -13.7% among women.

Figure 1 shows the distribution of changes in weight in the three different time periods: the right asymmetry of the first histogram (panel A) reveals that during the COVID-19 lockdown, an increase in weight occurred in the majority of the participants (50.8%). The third histogram (panel C), showing weight change after two years from the start of COVID-19 pandemic compared to before, shows a less asymmetric shape. However, an increase in weight persisted in the majority of the participants (47.3%).

Figure 2 shows the distribution of changes in PA in the three different time periods: the first histogram (panel A), left asymmetric, shows a substantial decrease in the average time spent for PA during the COVID-19 lockdown (in 53.1% of participants). The second histogram (panel B), showing changes that occurred after two years from the start of the pandemic compared to during the lockdown, is mirrored by the first histogram, showing a re-start in PA. The third histogram (panel C), showing changes after two years from the beginning of the COVID-19 pandemic compared to before the pandemic, shows a re-normalization in the time spent in

Table 1

Distribution on 4,831 Italian adults aged 18-74 years, according to their weight, body mass index (BMI) and physical activity, before the COVID-19 lockdown (February 2020), during the COVID-19 lockdown (April-May 2020) and at follow-up (February-March 2022)

	Total (N=4,831)			Men (N=2,487)			Women (N=2,344)		
	Feb 2020	Apr 2020	Mar 2022	Feb 2020	Apr 2020	Mar 2022	Feb 2020	Apr 2020	Mar 2022
Weight (kg), mean (SD)	72.9 (16.2)	73.8 (16.6)	73.4 (15.8)	79.9 (14.1)	81.0 (14.4)	80.5 (13.8)	65.4 (14.9)	66.2 (15.3)	65.9 (14.3)
BMI (kg/m²), mean (SD)	25.0 (4.9)	25.4 (5.0)	25.2 (4.6)	25.8 (4.1)	26.1 (4.2)	26.0 (4.0)	24.2 (5.4)	24.6 (5.6)	24.4 (5.1)
BMI categories (kg/m²)									
Under/normal weight (<25.0)	56.8	53.3	53.8	48.9	44.3	45.5	65.1	62.8	62.5
Overweight (25.0-29.9)	30.9	32.1	32.9	38.4	40.4	40.7	22.9	23.4	24.5
Obese (≥30)	12.4	14.6	13.4	12.7	15.3	13.8	12.0	13.9	12.9
Obese class I (30.0-34.9)	9.4	11.2	10.1	10.0	12.2	11.1	8.7	10.0	9.1
Obese class II (35.0-39.9)	2.0	2.5	2.4	1.9	2.3	2.2	2.1	2.6	2.7
Obese class III (≥40)	1.0	1.0	0.8	0.7	0.8	0.5	1.2	1.2	1.2
Physical activity (hours per week), mean (SD)	4.2 (4.9)	2.3 (4.0)	4.1 (5.9)	4.6 (5.0)	2.3 (3.7)	4.6 (5.9)	3.8 (4.9)	2.2 (4.2)	3.6 (5.8)
Physical activity categories (hours per week)									
0	23.7	45.3	23.2	20.2	43.7	19.7	27.5	46.9	27.0
1-3	29.9	32.0	36.1	28.4	33.4	34.5	31.5	30.6	37.7
4-6	26.0	13.9	23.0	28.2	14.3	25.1	23.6	13.5	20.7
7+	20.4	8.8	17.8	23.2	8.6	20.7	17.4	9.0	14.7

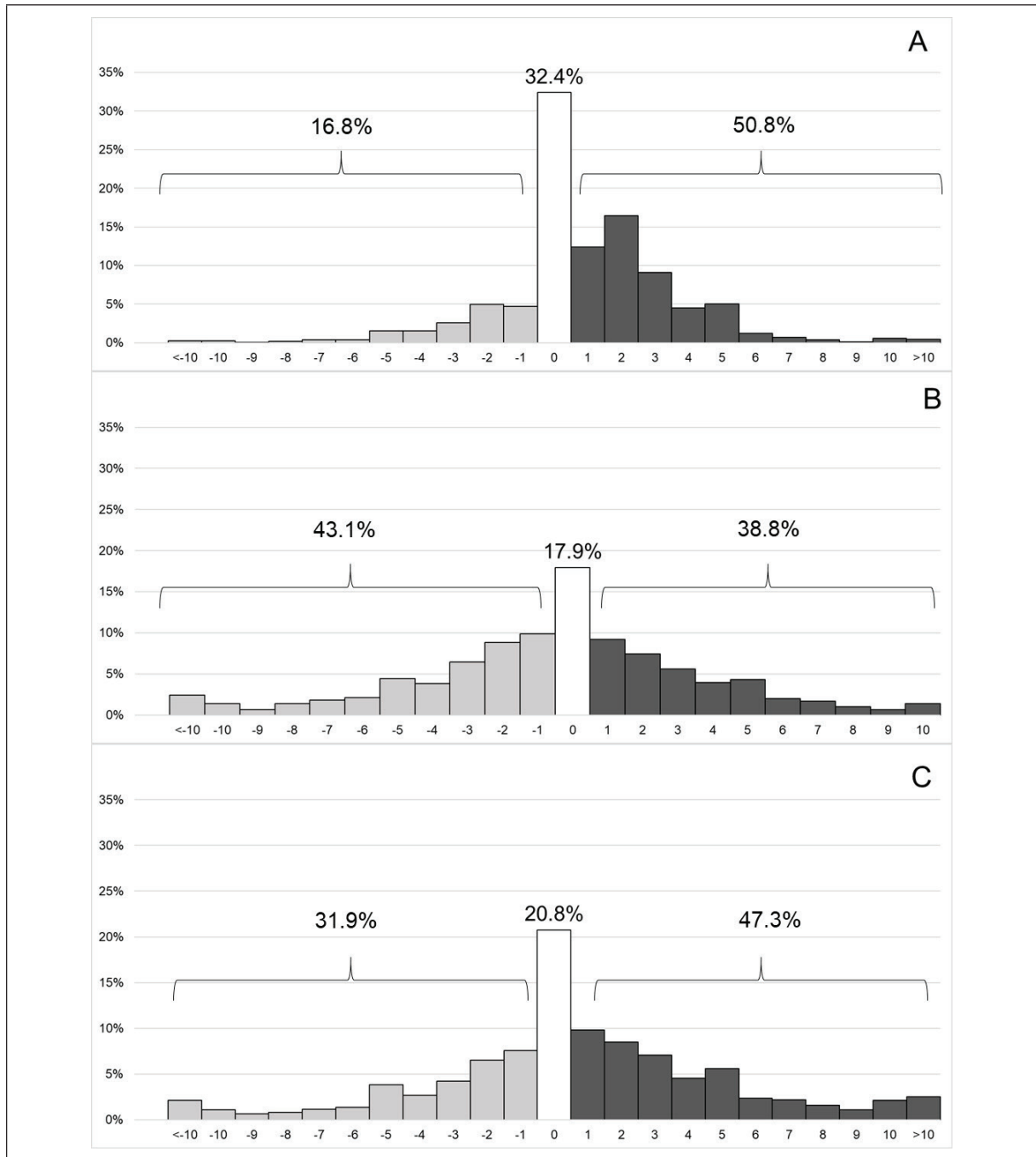N: number; BMI: body mass index; SD: standard deviation.

Figure 1

Distribution (%) of 4,831 Italian adults aged 18-74 years, according to a change in weight (kg). Panel A: during the COVID-19 lockdown (April-May 2020) compared to before the COVID-19 lockdown (February 2020); panel B: at follow-up (February-March 2022) compared to during the COVID-19 lockdown; and panel C: at follow-up compared to before the COVID-19 lockdown.

PA, revealing a more balanced distribution of those who increased (32.8%) and decreased (40.4%) the average time spent in PA.

Overall, 47.3% of participants increased their weight by at least 1 kg after two years from the beginning of the pandemic, and 17.4% increased by at least 5 kg (*Table 2*). In the same period, a decrease in PA by at least one h/w occurred in 40.5% of the participants and a decrease by at least 4 h/w was reported in 32.8% of the subjects. Participants increasing their weight by at least 5 kg were more frequently younger people (p for trend <0.001), with a lower level of education (p for trend =0.002) and from southern Italy or Islands (OR=1.35; 95% CI: 1.13-1.60) compared to northern Italy. Participants decreasing their PA by at least 4 h/w were more frequently from southern Italy or Islands, compared to those from northern Italy (OR=1.36; 95% CI: 1.10-1.68). No significant association was observed between sex, age, marital status, municipality size, and household characteristics, and both an increase in weight and a decrease in PA.
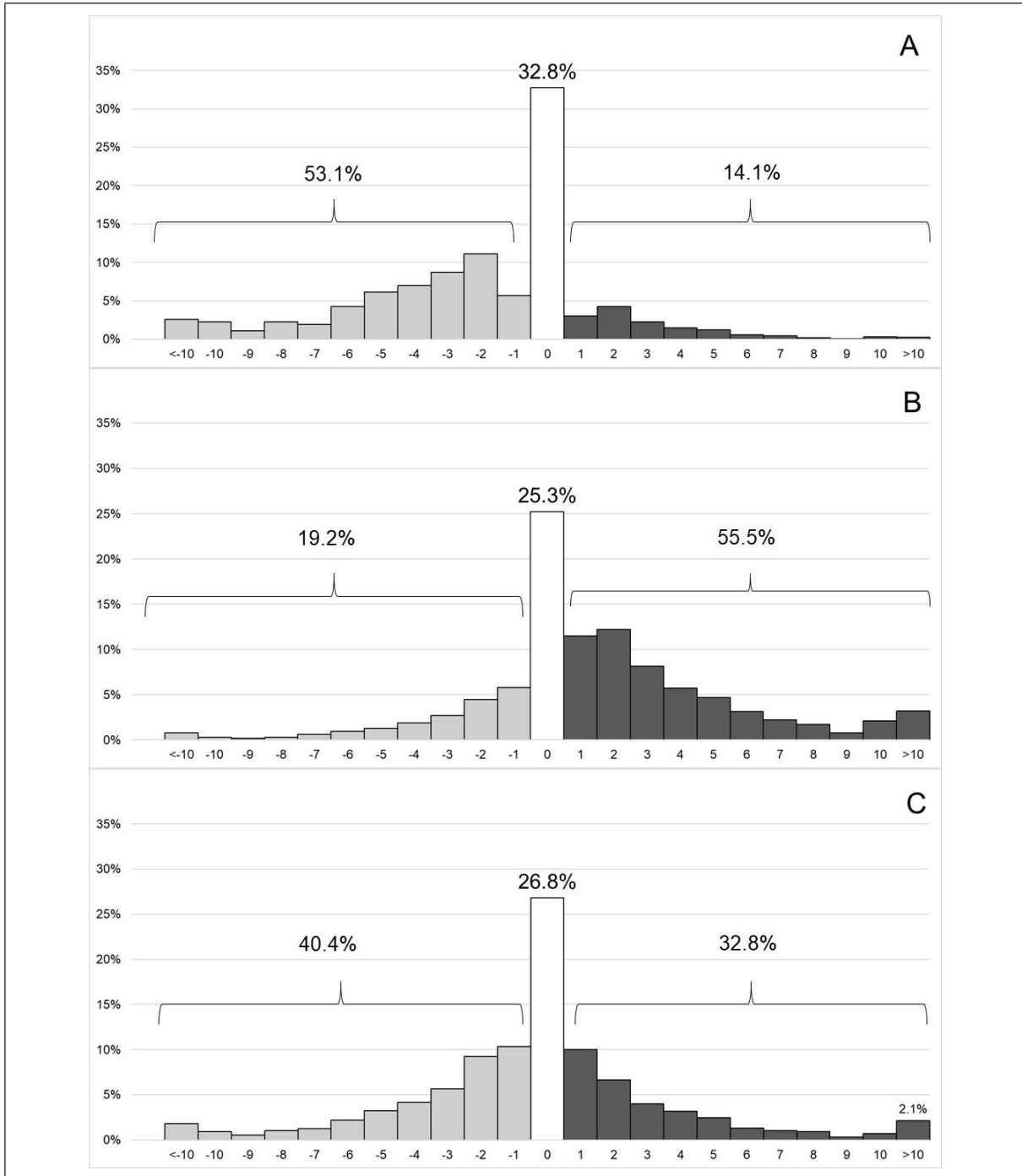
Figure 2
Distribution (%) of 4,831 Italian adults aged 18-74 years, according to a change in hours per week (h/w) of physical activity. Panel A: during the COVID-19 lockdown (April-May 2020) compared to before the COVID-19 lockdown (February 2020); panel B: at follow-up (February-March 2022) compared to during the COVID-19 lockdown; and panel C: at follow-up compared to before the COVID-19 lockdown.

An increase in weight by 5 kg or more was more frequent in participants who reported, during the two years from the start of the pandemic, a decrease in PA (OR=1.37; 95% CI: 1.17-1.59), in quality of life (OR=1.27; 95% CI: 1.09-1.48), in sleep quality (OR=1.20; 95% CI: 1.02-1.41), and an increase in anxiety symptoms (OR=1.20; 95% CI: 1.03-1.40) and depressive symptoms (OR=1.22; 95% CI: 1.04-1.42; *Table*

3). A decrease in PA by 4 h/w or more was more frequently reported in participants who, in the two years from the start of the COVID-19 pandemic, reported an increase in their weight (OR=1.37; 95% CI: 1.14-1.63), a decrease in quality of life (OR=1.20; 95% CI: 1.01-1.43) and an increase in anxiety symptoms (OR=1.23; 95% CI: 1.02-1.48).

Supplementary Table 2 (available online) shows the

Table 2

Distribution of 4,831 Italian adults, according to an increase in weight by 5 kg or more and a decrease in physical activity by 4 hours per week (h/w) or more at follow-up (February-March 2022) compared to before lockdown (February 2020), overall and by selected socio-demographic characteristics. Odds ratios[a] (OR) and 95% confidence intervals (CI). Italy

Characteristics	N	Increase in weight by 5 kg or more at follow-up compared to before COVID-19		N[b]	Decrease in physical activity by 4 h/w or more at follow-up compared to before COVID-19	
		%	OR (95% CI)		%	OR (95% CI)
Total	4,831	17.4		2,241	32.8	
Sex						
Men	2,487	17.3	1.00[c]	1,279	32.1	1.00[c]
Women	2,344	17.5	0.99 (0.85-1.15)	962	33.9	1.10 (0.92-1.32)
Age group						
18-34	1,062	20.8	1.00[c]	497	32.8	1.00[c]
35-54	2,228	17.9	0.86 (0.71-1.03)	998	31.6	0.97 (0.77-1.23)
55-74	1,541	14.4	**0.63 (0.51-0.77)**	746	34.6	1.13 (0.88-1.44)
P for trend			**<0.001**			0.280
Level of education						
Low	662	20.4	1.00[c]	267	37.1	1.00[c]
Intermediate	2,322	17.8	0.82 (0.66-1.02)	1,042	31.3	0.76 (0.57-1.01)
High	1,847	15.9	**0.70 (0.55-0.88)**	932	33.4	0.85 (0.64-1.14)
P for trend			**0.002**			0.738
Geographic area						
North	2,700	16.0	1.00[c]	1,289	30.6	1.00[c]
Center	841	17.2	1.11 (0.90-1.36)	406	34.0	1.16 (0.92-1.47)
South and Islands	1,290	20.5	**1.35 (1.13-1.60)**	546	37.4	**1.36 (1.10-1.68)**
Marital status						
Married	3,315	17.4	1.00[c]	1,564	32.2	1.00[c]
Divorced/separated	316	17.4	1.10 (0.81-1.50)	132	40.2	1.44 (0.99-2.08)
Widowed	69	10.1	0.60 (0.27-1.34)	26	38.5	1.33 (0.60-2.98)
Single	1,131	17.9	0.90 (0.74-1.08)	519	32.6	1.03 (0.82-1.30)
Municipality size (inhabitants)						
<10,000	984	18.8	1.00[c]	439	33.7	1.00[c]
10,000-100,000	2,179	16.9	0.87 (0.71-1.06)	1,009	32.5	0.92 (0.73-1.18)
100,000+	1,668	17.3	0.94 (0.76-1.16)	793	32.8	0.94 (0.73-1.22)
P for trend			0.721			0.723
Number of people at home						
1	519	16.6	1.00[c]	250	35.2	1.00[c]
2-3	2,810	17.3	0.99 (0.77-1.28)	1,297	33.2	0.88 (0.66-1.17)
4+	1,502	17.9	0.97 (0.74-1.27)	694	31.4	0.80 (0.59-1.09)
P for trend			0.783			0.153
Children 0-14						
Yes	1,453	18.2	1.02 (0.86-1.21)	665	31.4	0.93 (0.76-1.15)
No	3,378	17.1	1.00[c]	1,576	33.4	1.00[c]

N: number.

[a]Estimated with unconditional multiple logistic regression models after adjustment for sex, age, level of education and geographic area; estimates in bold type are statistically significant at 0.05.

[b]This analysis is based on subjects who did some physical activity before the lockdown. Thus, 2,590 subjects were excluded because they were inactive (physical activity of 0 h/w) before the beginning of the lockdown.

[c]Reference category.

Table 3

Distribution of 4,831 Italian adults, according to an increase in weight by 5 kg or more and a decrease in physical activity by 4 hours per week (h/w) or more at follow-up (February-March 2022) compared to before lockdown (February 2020), overall and by a change in selected lifestyle habits and mental health characteristics. Odds ratios[a] (OR) and 95% confidence intervals (CI). Italy

Characteristics	N	Increase in weight by 5 kg or more at follow-up compared to before COVID-19		N[b]	Decrease in physical activity by 4 h/w or more at follow-up compared to before COVID-19	
		%	OR (95% CI)		%	OR (95% CI)
Total	4,831	17.4		2,241	32.8	
Increased weight						
Yes				1,119	36.4	**1.37 (1.14-1.63)**
No				1,122	29.3	1.00[c]
Decreased physical activity						
No	2,877	15.7	1.00[c]			
Yes	1,954	20.0	**1.37 (1.17-1.59)**			
Decreased quality of life						
No	2,622	15.9	1.00[c]	1,184	31.0	1.00[c]
Yes	2,209	19.3	**1.27 (1.09-1.48)**	1,057	34.9	**1.20 (1.01-1.43)**
Decreased sleep quantity						
No	2,893	16.7	1.00[c]	1,315	32.2	1.00[c]
Yes	1,938	18.6	1.13 (0.97-1.32)	926	33.8	1.07 (0.89-1.28)
Decreased sleep quality						
No	3,467	16.6	1.00[c]	1,589	32.2	1.00[c]
Yes	1,364	19.4	**1.20 (1.02-1.41**)	652	34.4	1.10 (0.90-1.33)
Increased anxiety symptoms						
No	3,080	16.4	1.00[c]	1,430	31.2	1.00[c]
Yes	1,751	19.2	**1.20 (1.03-1.40)**	811	35.8	**1.23 (1.02-1.48)**
Increased depressive symptoms						
No	3,167	16.4	1.00[c]	1,483	31.8	1.00[c]
Yes	1,664	19.5	**1.22 (1.04-1.42)**	758	34.8	1.13 (0.94-1.37)

N: number.
[a]Estimated with unconditional multiple logistic regression models after adjustment for sex, age, level of education and geographic area; estimates in bold type are statistically significant at 0.05.
[b]This analysis is based on subjects who did some physical activity before the lockdown. Thus, 2,590 subjects were excluded because they were inactive (physical activity of 0 h/w) before the beginning of the lockdown.
[c]Reference category.

ORs of an increase by at least 5 kg in weight and a decrease by 4 h/w in PA, according to selected lifestyle habits and addictive behaviours. An increase in weight and a decrease in PA were more frequently reported with increasing BMI (p for trend=0.020 and p for trend <0.001, respectively). Weight gain occurred more frequently in current smokers (OR=1.22; 95% CI: 1.03-1.45) compared to never smokers. Subjects doing PA 7 or more h/w before the lockdown, more frequently reduced their activity after two years compared to those doing 4-6 h/w (OR=5.11; 95% CI: 4.21-6.21).

DISCUSSION

Using a prospective cohort study, we provide for the first time in Italy the long-term effects of the COVID-19 pandemic on weight gain and PA. During nation-wide COVID-19 lockdown, weight gain occurred in 51% and weight loss in 17% of the participants, whereas after two years from the beginning of the COVID-19 pandemic, weight gain persisted in 47% and weight loss in 32% of the sample. Although PA halved during the COVID-19 lockdown (from 4.2 h/w to 2.3 h/w), it almost re-reached pre-pandemic levels in the following two years. However, the proportion of more active individuals (practicing 4 h/w or more of physical activity) declined two years after the start of the pandemic.

In line with extensive literature from European and non-European studies, [12, 24] during the COVID-19 lockdown we observed an increase in body weight in the Italian adult population. During the lockdown, forced physical inactivity coupling with altered eating habits (e.g., an increased consumption of snacks and comfort food [15]), often associated with stress and emotional turmoil, have led the nutritional energy balance towards weight increase with calorific intake exceeding expenditure [25]. Our data reveal that, two years after the beginning of the COVID-19 pandemic, although weight gain has greatly receded, weight was still higher in approximately 50% of the population. Thus, it is possible that the changes in eating habits occurred during

the lockdown, combined with working from home and increased take-away food purchases, [15, 26, 27] may have persisted over time causing long-term effects.

PA sharply decreased during COVID-19 lockdown. This is in line with two systematic reviews, one based on 23 Italian studies and the second on 18 international studies, showing a significant reduction in PA during the COVID-19 lockdown compared to before the pandemic [13, 24]. Nevertheless, after two years from the beginning of the COVID-19 lockdown we observed an approximate re-normalization in PA habits in the general population.

Overall, our data reveal that the sub-groups of the population who got mostly hit by the pandemic were those from the South of Italy and the Italian islands, the least wealthy areas of the country, and those with a lower level of education. Economic hardship already present prior the pandemic may have further limited the dietary choices. Food insecurity, intensified by job losses and economic uncertainty, may have encouraged purchasing of cheap, poor quality foods with heavily processed, energy-dense nutrient-poor products [28] and discouraged purchasing and consumption of healthy fresh items [25]. A study on Italian older adults [27], evaluating changes towards a Mediterranean lifestyle occurring during the lockdown, revealed a global improvement in the adherence to the Mediterranean diet in the Italian population, partly explained by an increased time spent for home food preparation, typical feature of traditional healthy diets. However, changes were disproportionately distributed across socioeconomic strata, with higher level of education and wealth being independent predictors of improvements in line with a Mediterranean lifestyle during the COVID-19 pandemic. Moreover, low socioeconomic status and educational level have long been linked with fewer opportunities for PA [24] and this aspect may have been exacerbated after the lockdown.

The COVID-19 pandemic has been associated with increased levels of stress, anxiety and depression in the general population [4-6, 29] and these are associated with unhealthy eating patterns and sedentary behaviours [30]. In line with a recent study [31], we identified decreased sleep quality as a risk factor for weight gain. Moreover, people who gained body weight and decreased PA were more likely to report in the same period higher levels of stress and anxiety, and a worsened quality of life [3, 26]. These results suggest that, despite average levels of PA and body weight have tended to rereach pre-pandemic periods, the population subgroups on whom the pandemic has left major effects are the most fragile ones, characterized by impaired mental health.

The main strength of this study is that the survey was carried out longitudinally on a sample of the population aged 18-74 years, since most studies on this topic are cross sectional surveys. This enabled us to individually observe the long-term effects of COVID-19 pandemic on weight gain and PA in the Italian population. Future follow-ups of this cohort would allow us to evaluate the implications of the pandemic on a longer time period. Another strength of this study is the large sample size that allowed us to observe small differences. Limitations of our study include the self-reported anthropometric and physical activity data. More importantly, a possible selection bias cannot be ruled out, being this study based on a sample of online panelists, characterized by a higher socio-economic level compared with the general population. Another limitation worth to be mentioned is that we did not have the possibility to consider the differential application of the restriction measures in the different regions during the considered time period, which may have had an influence on changes in body weight and physical activity.

CONCLUSIONS

In conclusion, the study shows that, after two years from the start of the COVID-19 pandemic, although we have observed a trend toward a renormalization of body weight and PA in the Italian population, the segments of the population that remain most affected by the pandemic are the less wealthy and educated ones and the most fragile from a mental health perspective. Therefore, campaigns aimed at promoting healthy lifestyles and correct dietary habits need to target these at-risk subgroups.

Authors' contributions

All Authors conceptualized and designed the study. AO, RP and GC provided data. CS analysed the data under the supervision of SG and AL. CS, SG and AL wrote the first draft of the manuscript. PAvdB and AO provided important intellectual supports in various steps of the study. All Authors provided important contributions for the interpretation of findings and carefully revised the final version of the manuscript. All Authors have read and approved the last version of the manuscript.

Data availability statement

Data that support the findings of this study and materials are available from the corresponding Author, SG, upon reasonable request.

Conflict of interest statement

The Authors declared no conflict of interest.

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