Research article

The impact of physical activity on psychological health during Covid-19 pandemic in Italy

Grazia Maugeri\textsuperscript{a}, Paola Castrogiovanni\textsuperscript{a}, Giuseppe Battaglia\textsuperscript{b}, Roberto Pippi\textsuperscript{c}, Velia D'Agata\textsuperscript{a}, Antonio Palma\textsuperscript{b}, Michelino Di Rosso\textsuperscript{a}, Giuseppe Musumeci\textsuperscript{a,d,e,*}

\textsuperscript{a} Department of Biomedical and Biotechnological Sciences, Human, Histology and Movement Science Section, University of Catania, Via S. Sofia n° 87, 95123, Catania, Italy

\textsuperscript{b} Department of Psychology, Educational Science and Human Movement, University of Palermo, Via Giovanni Pascoli, 6, 90144, Palermo, Italy

\textsuperscript{c} Healthy Lifestyle Institute, C.U.R.I.A.Mo (Centro Universitario Ricerca Interdipartimentale Attività Motoria), University of Perugia, Via G. Bambagioni, 19 06126 Perugia, Italy

\textsuperscript{d} Research Center on Motor Activities (CRAM), University of Catania, Via S. Sofia n° 97, 95123, Catania, Italy

\textsuperscript{e} Department of Biology, Sbarro Institute for Cancer Research and Molecular Medicine, College of Science and Technology, Temple University, Philadelphia, PA 19122, USA

ARTICLE INFO

Keywords:
Exercise
Epidemiology
Public health
Psychology
COVID-19
Pandemic
Quarantine
Physical activity
Home based exercise
IPAQ-SF
Psychological well-being
PGWBI

ABSTRACT

The worldwide spread of COVID-19 has upset the normality of Italian daily life, forcing population to social distancing and self-isolation. Since the containment precautions also concern sport-related activities, home workout remained the only possibility to play sports and stay active during the pandemic.

The present study aimed to examine changes in the physical activity levels during self-quarantine in Italy, and the impact of exercise on psychological health.

A total of 2974 Italian subjects has completed an online survey, but only 2524 subjects resulted eligible for this study. The questionnaire measured the total weekly physical activity energy expenditure before and during quarantine (i.e. the sum of walking, moderate-intensity physical activities, and vigorous-intensity physical activities) in Metabolic Equivalent Task minutes per week (MET\textsuperscript{–}min/wk) using an adapted version of International Physical Activity Questionnaire and their psychological well-being using the Psychological General Well Being Index. Of the 2524 Italian subjects included in the study, 1426 were females (56.4%) and 1098 males (43.6%). Total physical activity significantly decreased between before and during COVID-19 pandemic (Mean: 2429 vs. 1577 MET\textsuperscript{–}min/wk, ****p < 0.0001), in all age groups and especially in men (Female, mean: 1994 vs. 1443 MET\textsuperscript{–}min/wk, ****p < 0.0001; Male, mean: 2998 vs. 1754 MET\textsuperscript{–}min/wk, ****p < 0.0001). Furthermore, a significant positive correlation was found between the variation of physical activity and mental well-being (r = 0.07541, ***p = 0.0002), suggesting that the reduction of total physical activity had a profoundly negative impact on psychological health and well-being of population.

Based on this scientific evidence, maintaining a regular exercise routine is a key strategy for physical and mental health during a forced rest period like the current coronavirus emergency.

1. Introduction

In late December 2019, an epidemic of cases with unknown low respiratory infections occurred in Wuhan, the largest metropolitan area in China's Hubei province. This disease was caused by a new coronavirus (CoV) named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), responsible of the coronavirus disease 2019 (COVID-19) as announced by World Health Organization (WHO) on 11 February 2020.

In the following weeks, infections spread across China and other countries, including Italy, and COVID-19 epidemic has become a global health threat. In Italy, according to last updated of the Italian Ministry of Health (May 1, 2020 at 6.00 pm) it has been turned out 17,569 patients with symptoms, 1,578 intensive care, 81,769 home isolation, 100,943 total currently positive, 78,249 dismissed/healed, 28,236 deaths, 207,428 total cases [1]. Total infected and total death by Italian regions is displayed in Table 1. The Italian patients’ median age was 62 years, the

* Corresponding author.
E-mail address: g.musumeci@unict.it (G. Musumeci).

https://doi.org/10.1016/j.heliyon.2020.e04315
Received 12 May 2020; Received in revised form 14 June 2020; Accepted 22 June 2020
2405-8440/© 2020 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Long term counteract metabolic disorder, bone, muscle, joint pathologies and activity to ameliorate general health, acting on heart, circulatory and pulmonary system. Literature has largely described the positive role exerted by physical activity against the pathogen, leading to cell damage and necrosis [19, 20]. Several evidences have also demonstrated that physical activity can be effective in ameliorating the mental well-being and having the potential to prevent symptoms of mental health disorder such as depression and anxiety [21, 22, 23, 24]. Based on these evidences, the capacity, loss of muscle strength and mass, tendon ruptures and reduced joint tribology [18]. Regular physical activity is a key health behaviour from a public health perspective, as it has a remarkable impact on health. In respect to upper respiratory tract infection (URTI), caused by pathogens like COVID-19, physical activity may ameliorate pathological outcomes, by promoting the release of stress hormones responsible for reducing excessive local inflammation within the respiratory tract and by inducing the secretion of anti-inflammatory cytokines, such as IL-4 and IL-10, in order to prevent excessively prolonged T helper type 1 (Th1) cell population activity against the pathogen, leading to cell damage and necrosis [19, 20]. Several evidences have also demonstrated that physical activity can be effective in ameliorating the mental well-being and having the potential to prevent symptoms of mental health disorder such as depression and anxiety [21, 22, 23, 24]. Based on these evidences, the purpose of this survey study was to examine (1) changes in the physical activity levels during self-quarantine in Italy; (2) the correlation between physical activity and well-being of individuals. To this end, it has been used an online questionnaire containing an adapted version of short-form of International Physical Activity Questionnaire (IPAQ-SF), to assess the practised level of physical activity and Metabolic Equivalents (MET) energy expenditure, and the Psychological General Well Being Index (PGWBI) to evaluate psychological and general well-being.

2. Materials and methods

2.1. Design

The present study is a quick, large cross-sectional online survey realized through Google Forms web survey platform (Google LLC, Mountain View, CA, United States). The online survey was communicated through the social media such as Instagram, LinkedIn, Facebook and via official channels of the University of Catania, University of Palermo, University of Perugia and by the Italian Society of Movement and Sport Sciences (SISMES). Moreover, via WhatsApp and e-mails, it was shared to personal contacts of the research group members and of the University students. Before starting the questionnaire, the online survey, totally anonymous and not traceable to identity of participants, including a brief description of the study, its aim, and the declarations of

### Table 1. Contagions of COVID-19 in Italy by region at 13th of June 2020. [https://lab24.ilsole24ore.com/coronavirus/](https://lab24.ilsole24ore.com/coronavirus/).

| Italian Regions               | Total Italian population currently positive 28,997 | Total Cases From the beginning of the Epidemic 236,305 | Total Italian population currently Deaths 34,223 | Total Italian population currently Healed 173,085 |
|-------------------------------|--------------------------------------------------|------------------------------------------------------|-------------------------------------------------|-----------------------------------------------|
| Lombardia                     | 91,204                                           | 16,405                                               | 57,775                                          |                                               |
| Piemonte                      | 30,989                                           | 3,996                                                | 24,096                                          |                                               |
| Emilia Romagna                | 28,028                                           | 4,196                                                | 22,015                                          |                                               |
| Veneto                        | 19,199                                           | 1,967                                                | 16,383                                          |                                               |
| Toscana                       | 10,165                                           | 1,080                                                | 8,575                                           |                                               |
| Liguria                       | 9,871                                            | 1,516                                                | 8,166                                           |                                               |
| Lazio                         | 7,916                                            | 781                                                  | 4,913                                           |                                               |
| Marche                        | 6,752                                            | 993                                                  | 5,009                                           |                                               |
| Campania                      | 4,608                                            | 430                                                  | 3,832                                           |                                               |
| Trentino Alto Adige           | 7,051                                            | 755                                                  | 6,127                                           |                                               |
| Puglia                        | 4,515                                            | 532                                                  | 3,544                                           |                                               |
| Sicilia                       | 3,455                                            | 279                                                  | 2,335                                           |                                               |
| Friuli Venezia Giulia         | 3,290                                            | 342                                                  | 2,840                                           |                                               |
| Abruzzo                       | 3,271                                            | 453                                                  | 2,290                                           |                                               |
| Umbria                        | 1,436                                            | 76                                                   | 1,336                                           |                                               |
| Sardegna                      | 1,363                                            | 131                                                  | 1,190                                           |                                               |
| Valle d’Aosta                 | 1,191                                            | 144                                                  | 1,038                                           |                                               |
| Calabria                      | 1,161                                            | 97                                                   | 1,017                                           |                                               |
| Basilicata                    | 401                                              | 27                                                   | 362                                             |                                               |
| Molise                        | 439                                              | 23                                                   | 302                                             |                                               |
anonymity and confidentiality as follow: “The data of this survey are anonymous, confidential and their confidentiality will be guaranteed. We remind you that participation is voluntary and therefore, can withdraw or renounce at any time. The participant, informed according to the methods and purposes of the research described above, expresses his/her consent to his/her participation, having the guarantee that his/her personal data will be processed anonymously”. All subjects participating in the online survey gave their informed consent before participation. The study was approved by the local ethics committee of the Research Center on Motor Activities (CRAM), University of Catania (Protocol Number: CRAM-011-2020-16/03/2020), and it was conducted in accordance with the Declaration of Helsinki.

2.2. Participants

A total of 2974 Italian subjects of different social classes and level of instruction completed the online Google form questionnaire over a period of 30 days (from April 1st to April 30th, 2020) during COVID-19 emergency in Italy. To minimize the impact of errors, a cleaning process was adopted in order to remove ineligible cases identify meaningless data, representing invalid questionnaire responses due to the unwillingness of the participant to provide a valid response according to American Association for Public Opinion Research addressed in “Standard Definitions” [25]. Then, the sample comprised 2524 Italian subjects, 1426 females (56.4%) and 1098 males (43.6%), was included in the study.

2.3. Questionnaire

The online questionnaire (https://forms.gle/8254mc5WicKeKs6nDz8) administered to the participants included five explanations of the kind of physical activity and 55 questions comprising demographic, anthropometric, socioeconomic data and health status shown in Table A of supplementary materials, an adapted version of short-form of International Physical Activity Questionnaire (IPAQ-SF) and the Psychological General Well Being Index (PGWBI). The questions of IPAQ-SF allowed to assess physical activity by providing information about the minutes per day or days per week, at any time of the day, spent doing activities before COVID-19 emergency and in the last four weeks. Participants reported the frequency and duration of different types of activity: vigorous (i.e. heavy lifting, performing intense aerobic exercises, using bike or treadmill); moderate (i.e. carrying light loads or performing aerobic exercises at a regular pace, work out in the garden); walking activities, as well as the average time, spent sitting on a weekday, including sitting at work. Responses were converted to Metabolic Equivalent Task minutes per week (MET-min/week) though automatic scoring of the IPAQ-S [26]. Based on the IPAQ recommendations for scoring protocol, participants of the study was classified in three different groups of physical activity considering the MET–min/wk of the sum of walking, moderate-intensity physical activities, and vigorous-intensity physical activities: low active (<600 MET–minutes/week); moderate active (>600 MET–minutes/week) and high active (>3000 MET–minutes/week) (http://www.ipaq.ki.se).

To estimate a subjective perception of well-being in the last four weeks during COVID-19 emergency, the online questionnaire also comprised 22 items of PGWBI, which evaluate psychological and general well-being of subjects in six health-related quality of life domains comprising: anxiety, depressed mood, positive well-being, self-control, general health and vitality. Each response has six possible scores from 0 (most negative option) to 5 (most positive option), and the global summary between 0 and 60 reflect severe distress, between 61 and 72 reflect moderate distress, and between 73 and 110 points to positive psychological well-being, with a maximum of 110 points, representing the best achievable level of well-being [27].

2.4. Statistical analysis

Statistical analysis was performed using GraphPad Instat® Biostatistics version 3.0 software (GraphPad Software, Inc. La Jolla, CA, USA). Analysis of variance (1way ANOVA, Kruskal-Wallis test with Dunn’s multiple comparisons test) was used for comparison between more than two groups; Unpaired t test with Welch’s correction was used for comparison between two groups. p-values of less than 0.05 were considered to be statistically significant (**p < 0.05; ***p < 0.01; ****p < 0.001); ****p < 0.0001 and ns: not significant). Data are presented as the Mean ± SEM. The relationships between physical activity and psychological well-being were assessed by Pearson correlation analysis.

3. Results

3.1. General characteristics of the study populations

Baseline characteristics of the study subjects are displayed in Table 2. Overall, the study sample (n = 2524) comprised 56.4% of females and 43.6% of males. Participants were divided into four age groups: young aged <21 (n = 346); young adult aged 21–40 (n = 1178); adults aged 41–60 (n = 704) and over 60 age (n = 296). The mean height was 171.80 ± 9.84, the weight 66.10 ± 13.66 kg, and body mass index (BMI) was 22.26 ± 3.52 kg/m². The BMI was then split into three categories: underweight (BMI < 18.5), normal weight (BMI 18.5–24.9) and overweight (BMI ≥25.0). As shown in Table 2, 66.63% of participants were classified as normal-weight subjects.

3.2. Comparison of physical activity before and during COVID-19 pandemic in Italy

Participants had to give information (before and during the COVID-19 quarantine) related to vigorous and moderate-intensity physical activity as well as walking activity and sedentary behaviours. Vigorous-intensity physical activities comprising heavy lifting, use of home gym machines, work out/courses on the online platform and others fitness instruments, demand a hard physical effort that increases the breathing rate more frequently than normal. Moderate-intensity physical activities can include carrying a light load or performing aerobic exercises at a modest intensity. Examination of the total physical activity in MET–minutes/week demonstrated a statistically significant difference between before and during COVID-19 pandemic (Mean: 2429 vs. 1577 MET–min/wk, p < 0.0001) (Figure 1A). Specifically, scores of vigorous physical activity (Mean: 1109 vs. 766.6 MET–min/wk, ****p < 0.0001), moderate activity (Mean: 574 vs. 523.3 MET–min/wk, *p = 0.0188) and walking (Mean: 746 vs. 287.6 MET–min/wk, ****p < 0.0001) of subjects during COVID-19 emergency were significantly lower than those of the period before quarantine (Figure 1A).

Results of the IPAQ scoring showed that before COVID-19 emergency 23.06% of participants were low active (<600 MET–minutes/week), 35.18% are moderate active (>600 MET–minutes/week) and 41.76% are high active (>3000 MET–minutes/week).

During COVID-19 quarantine, percentage of low active individuals increased up to 39.62%, whereas 29.75% and 30.63% were moderate active and high active, respectively (Table 3).

As shown in Figure 1B, the levels of physical activity of participants classified before COVID-19 as high active and moderate active, drastically decreased during COVID-19 pandemic (Mean: 4400 vs. 2432 MET–min/wk, ****p < 0.0001; Mean: 1354 vs. 1077 MET–min/wk, ****p < 0.0001, respectively). These results suggest that the limitations imposed by quarantine, have induced that part of population that usually performed moderate and high levels of physical activity to decrease their regular and habitual level during the forced period. On the contrary,
individuals classified before COVID-19 as low active significantly increased total weekly physical activity energy expenditure during quarantine (Mean: 408.1 vs 755.3 MET-min/wk, ****p < 0.0001). This unexpected result could be due to the greater housework activities carried out by these subjects forced to stay at homes, compared to before quarantine. Accordingly, the variation of MET–min/week (i.e. during vs before) is positive only in the low group. Moreover, Δ-MET values are statistically different among the three groups (****p < 0.0001) (Figure 1C).

Regarding gender classifications, total physical activity between before and during quarantine significantly decreased in MET–min/week in both groups (Female, mean: 1994 vs. 1443 MET–min/wk, ****p < 0.0001; Male, mean: 2998 vs. 1754 MET–min/wk, ****p < 0.0001).
PGWBI score. As shown in Figure 3A, a significant positive correlation was found between the variation of physical activity and mental well-being, suggesting that reduction of total physical activity is related to worse status of psychological well-being (r = 0.07541, ***p = 0.0002).

Interestingly, the correlation between physical activity and psychological well-being depending on gender showed a higher positive correlation in female (r = 0.1758, ***p < 0.0001) as compared to male group (r = 0.06556, *p = 0.0366), suggesting that variations in physical activity habits could more influence the psychological status of women than men (Figure 3B-C).

As shown in Figure 3E, a significant positive correlation was detected between the variation of total activity and PGWBI score in young adult group (r = 0.1168, ***p < 0.0001), whereas no significant association was found between physical activity and psychological well-being in the other age groups (Figure 3D-G).

Lastly, the same correlation was evaluated for the three categories of participants, classified before COVID-19, as high active, moderate active and low active. As shown in Figure 3H-I, a significant correlation was found in high active (r = 0.1322, ***p < 0.0001) and moderate active (r = 0.1035, **p = 0.0020) groups. No positive correlation between variation of total activity and PGWBI score was found in low active group (Figure 3L) (r = 0.08157, p = 0.0546).

Table 4. PGWBI subscales score by gender, age and physical activity levels.

|                  | Anxiety  | Depression | Positive well-being | Self-control | General health | Vitality | PGWBI total score |
|------------------|----------|------------|---------------------|--------------|----------------|----------|------------------|
|                  | Mean (SD) | Mean (SD) | Mean (SD)           | Mean (SD)    | Mean (SD)      | Mean (SD) | Mean (SD)        |
| **Gender**       |          |            |                     |              |                |          |                  |
| Female           | 17.68 (±0.80) | 9.68 (±0.15) | 13.77 (±1.06)       | 9.81 (±1.08) | 9.00 (±0.28)   | 12.06 (±0.45) | 72.00 (±16.13)  |
| Male             | 19.41 (±0.70) | 10.77 (±0.24) | 14.83 (±0.91)       | 10.72 (±1.05) | 10.54 (±0.31) | 13.75 (±0.41) | 80.03 (±13.72)  |
| **Age group**    |          |            |                     |              |                |          |                  |
| Young            | 18.45 (±0.75) | 10.16 (±0.18) | 14.24 (±0.98)       | 10.46 (±1.00) | 10.00 (±0.30) | 12.99 (±0.42) | 76.30 (±16.10)  |
| Young adults     | 18.45 (±0.76) | 10.19 (±0.18) | 14.27 (±0.99)       | 10.20 (±1.07) | 9.20 (±0.29)  | 12.76 (±0.43) | 75.07 (±16.04)  |
| Adults           | 18.51 (±0.74) | 10.16 (±0.19) | 14.22 (±0.98)       | 10.22 (±1.06) | 9.82 (±0.28)  | 12.82 (±0.44) | 75.75 (±14.71)  |
| Over 60          | 18.15 (±0.68) | 9.99 (±0.25)  | 14.12 (±1.03)       | 9.93 (±1.12)  | 9.51 (±0.29)  | 12.63 (±0.41) | 74.33 (±13.53)  |
| **Physical activity level during COVID-19 quarantine** |          |            |                     |              |                |          |                  |
| Low active       | 16.29 (±0.76) | 10.10 (±0.18) | 14.03 (±1.03)       | 10.13 (±1.09) | 9.29 (±0.31)  | 12.1 (±0.43) | 71.94 (±16.93)  |
| Moderate active  | 19.16 (±0.74) | 10.10 (±0.18) | 14.31 (±0.97)       | 10.18 (±1.09) | 9.90 (±0.26)  | 12.88 (±0.43) | 76.53 (±14.52)  |
| High active      | 18.62 (±0.75) | 12.05 (±0.20) | 14.42 (±0.96)       | 10.34 (±1.01) | 9.99 (±0.28)  | 12.95 (±0.43) | 78.37 (±14.48)  |

SD, standard deviation.
4. Discussion

The worldwide spread of the SARS-CoV-2 infection led the Italian Government to apply unprecedented containment measures. The Decree of the Italian Prime Minister of March 20, 2020 has been issued to state an absolute ban to get away from their home, except to make essential work or activities. Quarantine has upset the normativity of Italian daily life, forcing population to social distancing and self-isolation. The precautionary measures have also involved sport-related activities, including walking and running outside. Therefore, home workout remained the only possibility to play sports and stay active during Covid-19 pandemic. In the present work, we analyzed the total MET–min/week and total PGWBI score before- and during COVID-19 quarantine and assess the relationship with the psychological well-being of 2524 participants, of which 41.76% was classified as a highly active group. Certainly, our study sample is very limited compared to other work present in the literature, such as the work by Jin and coauthors which included more than 50000 individuals, even if the treated topic was different [28]. To date, in Italy is not present a national health monitoring and surveillance system for physical activity, and no studies have collected large data showing the different activity levels of the general public [29]. However, data for the years 2010–2013 from the survey by the Italian Ministry of Health’s Behavioural Risk Factor Surveillance System (Progressi delle Aziende Sanitarie per la Salute in Italia (PASSI)) [30], showed that 36% of Italian adults of 30–60 years and 24% of older adults of aged 60 + years meet the recommended physical activity levels. Moreover, in line with our results, a very recent study conducted on Sicilian population [31], showed that before COVID-19 quarantine, 44% and 50% of participants were moderate active and high active, respectively. Although the scientific community has highlighted the real benefits to stay active during the pandemic, our results showed a strong reduction of physical activity levels, especially for vigorous activity and walking. These data reflect the major difficulties to walk and perform an intense exercise at home, compared to moderate activity. The WHO recommends practising at least 150 min per week of moderate to vigorous-intensity physical activity or 75 min of high intensity per week, or a combination of both [29, 32]. Although running, fast swimming, playing basketball, soccer, represent vigorous-intensity activities burn more than 3000 MET–minutes/week, many other intense exercises can be performed staying at home, such as carrying/moving heavy load (>20 kg) or stair climbing. Stairs can be found in most private homes, and stair climbing (at least 10 min per day) is considered a vigorous-intensity activity [33]. An opposite trend was found for subjects classified as low active before COVID-19, whose total physical activity energy expenditure during quarantine significantly increased. This phenomenon could be due to a radical change in everyday schedules and habits. People remaining at home spend much more time in low-intensity activities like housework (cooking, washing dishes or gardening). Another reason could be the greater female presence in the study that is generally more prone to do low-intensity activities. Our study also showed that during the pandemic, the physical activity levels significantly decreased in all age groups considered. Moreover, the male group showed highly significant variation between before and during COVID-19 emergency as compared to the female group. Previous works have largely indicated gender differences in exercise habits and motivations for exercise [34, 35, 36, 37]. Men practice physical activity mainly for social and competitive reasons. Moreover, they prefer to practice sports, outdoor and/or in public places like the gym and fitness clubs. Females are more inclined to exercise in home-setting, practising aerobics, dancing, yoga, pilates or circuits with push-ups, squats, planks and jumping jacks. Furthermore, the lower variation in physical activity levels between before and during quarantine found in women is possibly explained by the higher amount of housework physical activity than males [37, 38]. Secondly, we investigated the impact of physical activity on psychological well-being during the pandemic. Our results showed that the reduction of physical activity levels is ever related to the worse status of psychological well-being. The positive effects of regular physical activity on psychological health are indisputable in the field of modern medicine. Regular exercise improves one’s self-esteem and a sense of well-being. Individuals who exercise regularly exhibit fewer depressive and anxiety symptoms, thus supporting the concept that physical activity provides a beneficial effect against the development of mental disorders [39]. Several studies have demonstrated that the anxiolytic effects of regular exercise are linked to change in hypothalamic-pituitary-adrenal (HPA) axis and meditation of the
endogenous opioid system, which are involved in stress reactivity, anxiety, mood and emotional responses [40, 41, 42]. Furthermore, physical activity is implicated in the modulation of different trophic factors, such as brain-derived neurotrophic factor (BDNF). BDNF, whose levels are upregulated following exercise, represents the most abundant neurotrophin in the brain, which positively influences both anxiety and depressive disorders [43]. We found that the correlation between the reduction of physical activity and psychological well-being is stronger in the female group. Previous studies have examined gender differences between measures of physical fitness and life satisfaction, that is one of the central constructs in the field of positive psychology. Although most of them reflecting no difference between genders and life satisfaction, some works demonstrated higher life satisfaction measures among females when compared with males. This evidence suggests that reduction of physical activity levels may mostly influence mental well-being of female group [44, 45, 46, 47]. The current study also showed a significant correlation between the change in total activity and the PGWBI score in subjects classified as high active and moderate active as well as in the young adult group. The latter result is supported by previous studies demonstrating the strong relationship between physical activity and psychological well-being in this age group [47, 48, 49].

Although the negative impact on psychological well-being due to the reduction of physical activity levels is a dogma, currently in the literature there is only one study conducted in Canada that can strengthen our present results, regarding the worsen of psychophysical conditions during a period of forced rest due to a pandemic [50]. Generally, it is the individual to choose if perform or not physical activity, but the COVID-19 spread changed the world. Gyms, stadiums, pools, dance and fitness studios, physiotherapy centres, parks and playgrounds were closed, compelling people to find alternatives to exercise. Consequently, different life habits have been affected, with the modification of routines of mobility, physical activity, and habitual exercise protocols. Under such unusual conditions, barriers to keep an active life's style were hard to overcome. For the above reasons, we studied the impact of physical activity on psychological health during Covid-19 pandemic in Italy. The benefits of exercise are proven very helpful, especially in times of anxiety, crisis and fear. There are concerns therefore that, in the context of the pandemic, lack of access to regular sporting or exercise routines resulted in challenges to the immune system, physical health, including by leading to the commencement of or exacerbating existing diseases that have their roots in a sedentary lifestyle. Lack of access to exercise and physical activity had also mental health impacts, compound stress or anxiety that many experienced in the face of isolation from normal social life. Possible loss of family or friends from the virus and impact of the virus on one's economic well-being and access to nutrition exacerbated these effects.

The limitations of this study included the over-reporting bias of physical activity as well as to report at the same time point, information related to exercise levels before- and during COVID-19. However, IPAQ questionnaires may supply a reliable approximation of physical activity at a population level, and its validity has been confirmed in different studies [51, 52].

5. Conclusion

In conclusion, our results, for the first time in the literature, have shown that quarantine in Italy induces a significant reduction of total weekly physical activity energy expenditure in all age groups and especially in men, and this reduction negatively affects the psychological well-being. In fact, physical activity has a profoundly positive impact on psychological health, by enhancing self-esteem and resilience to stress and reducing depression and anxiety. Given the spread of COVID-19, stay at home is a fundamental step to halt the pandemic. However, the clinical relevance of the present study denotes that maintaining regular physical activity is an important preventive strategy for physical and mental health during a forced rest period like the current coronavirus emergency. Then “stay active to feel better”.

Declarations

Author contribution statement

G. Maugeri: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

P. Castrogiovanni, G. Battaglia, R. Pippi, V. D’Agata, M. Di Rosa: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

A. Palma: Analyzed and interpreted the data; Wrote the paper.

G. Musumeci: Conceived and designed the experiments; Wrote the paper.

Funding statement

This work was supported by the University Research Project Grant (Triennial Research Plan 2016–2018), Department of Biomedical and Biotechnological Sciences (BIOMETEC), University of Catania, Italy.

Competing interest statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at https://doi.org/10.1016/j.heliyon.2020.e04315.

Acknowledgements

A special thank goes to all front-line health care workers worldwide (first responders, law enforcement officers, nurses, doctors and volunteers) for their unwavering and devoted commitment to all COVID-19 infected patients. We also thank firefighters, ecological operators, educators, healthcare personnel, pharmacists, biologists, psychologists, sport and exercise scientists, researchers and others that have contributed to guarantee the continuation of daily life. Humanity will forever be indebted to all of them. A particular thought also goes to all the victims of this pandemic and their families.

References

[1] Italian Ministry of health. http://www.salute.gov.it/nuovocoronavirus?gclid=Cj0KCQjwJL7TTBD9ARIdaMEc8BuyltIcdF_xzUT7r74.CwebyGHPZMIPNhxQPDvs7C 9DmZ8Wm4AArrC5JLw_wcC (Accessed 1 May 2020).

[2] Z. Wu, J.M. McGoogan, Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese center for disease control and prevention, JAMA 323 (13) (2020) 1239–1242.

[3] Q. Li, X. Guan, P. Wu, et al., Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. N. Engl. J. Med. 382 (13) (2020) 1199–1207.

[4] J.F.W. Chan, S. Yuan, K.H. Kok, et al., A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster, Lancet 395 (10233) (2020) 514–523.

[5] Y.R. Guo, Q.D. Cao, Z.S. Hong, et al., The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak - an update on the status, Mil. Med. Res. 7 (2020) 11.

[6] C.W. Lu, X.F. Liu, Z.F. Jia, 2019-nCoV transmission through the ocular surface must not be ignored, Lancet 395 (2020) e39.

[7] S.K. Brooks, R.K. Webster, L.E. Smith, et al., The psychological impact of quarantine and how to reduce it: rapid review of the evidence, Lancet 395 (10227) (2020) 912–920.

[8] W.M. Bortz II, The diuse syndrome, West. J. Med. 141 (5) (1984) 691–694.

[9] J. Rones, J. Wàrnberg, T. Pezo, A. Marcos, Physical activity, immunity and infection, Proc. Nutr. Soc. 69 (3) (2010) 390–399.

[10] N. Wu, S. Bredin, Y. Guan, et al., Cardiovascular health benefits of exercise training in persons living with type 1 diabetes: a systematic review and meta-analysis, J. Clin. Med. 8 (2) (2019) E263.
[11] G. Musumeci, Effects of exercise on physical limitations and fatigue in rheumatic diseases, World J. Orthoped. 6 (10) (2015) 762–769.

[12] P. Castigovannini, F.M. Trovato, M.A. Szychlinska, H. Nür, R. Imbesi, G. Musumeci, The importance of physical activity in osteoporosis. From the molecular pathways to the clinical evidence, Histol. Histopathol. 31 (11) (2016) 1183–1194.

[13] P. Castigovannini, M. Di Rosa, S. Ravalli, et al., Moderate physical activity as a prevention method for knee osteoarthritis and the role of synoviocytes as biological key, Int. J. Mol. Sci. 20 (3) (2019) 511.

[14] M.A. Szychlinska, P. Castrogiovanni, F.M. Trovato, et al., Physical activity and Mediterranean diet based on olive tree phenolic compounds from two different geographical areas have protective effects on early osteoarthritis, muscle atrophy and hepatic steatosis, Eur. J. Nutr. 58 (2019) 565–581.

[15] D.E. Warburton, C.W. Nicol, S.S. Bredin, Health benefits of physical activity: the evidence, CMAJ (Can. Med. Assoc. J.) 174 (6) (2006) 801–809.

[16] M. Nti, P. Castrogiovanni, S. Ravalli, et al., Moderate physical activity as a prevention method for knee osteoarthritis and the role of synoviocytes as biological key, Int. J. Mol. Sci. 20 (3) (2019) 511.

[17] B.K. Pedersen, B. Saltin, Evidence for prescribing exercise as therapy in chronic disease, Scand. J. Med. Sci. Sports 16 (1) (2006) 3–63.

[18] A. Paoli, G. Musumeci, Elite athletes and COVID-19 lockdown: future health concerns for an entire sector, J. Funct. Morphol. Kinesiol 5 (2020) 30.

[19] S.A. Paluska, T.L. Schwen, Physical activity and mental health, Sports Med. 29 (18) (2000) 167–180.

[20] K.R. Fox, The influence of physical activity on mental well-being, Publ. Health Nutr. 2 (3) (1999) 411–418.

[21] D. Scully, J. Kremer, M.M. Meade, R. Graham, K. Dudgeon, Physical exercise and psychological well-being: a critical review, Br. J. Sports Med. 32 (2) (1998) 111–120.

[22] K.R. Fox, The influence of physical activity on mental well-being, Publ. Health Nutr. 2 (3) (1999) 411–418.

[23] S.A. Paluska, T.L. Schwen, Physical activity and mental health, Sports Med. 29 (2000) 167–180.

[24] G.M. Cooney, K. Dwan, C.A. Greig, et al., Exercise for depression, Cochrane Database Syst. Rev. 12 (9) (2013) CD004366.

[25] Standard Definitions, Final Disposals of Case Codes and Outcome Rates for Surveys, American Association for Public Opinion Research, Oakbrook Terrace, IL, 2015. http://www.sapo.or.org/Publications-Media/AAPOR-Journals/Standard-Definitions.aspx. (Accessed 1 May 2020).

[26] H.L. Cheng, A Simple, Easy-To-Use Spreadsheet for Automatic Scoring of the Standard Definitions, Final Disposals of Case Codes and Outcome Rates for Surveys, American Association for Public Opinion Research, Oakbrook Terrace, IL, 2015. http://www.sapo.or.org/Publications-Media/AAPOR-Journals/Standard-Definitions.aspx. (Accessed 1 May 2020).

[27] H.J. Dupuy, The Psychological General Well-Being (PGWB) Index, in: N.E. Wenger, M.E. Mattson, C.D. Furberg, J. Elimon (Eds.), Assessment of Quality of Life in Clinical Trials of Cardiovascular Therapies, Le Jaqc Publishing, New York, 1984, pp. 170–183.

[28] M.N. Jin, P.S. Yang, C. Song, et al., Physical activity and risk of atrial fibrillation: a nationwide cohort study in general population, Sci. Rep. 9 (1) (2019) 12270.

[29] G. Musumeci, Physical activity for health—an overview and an update of the physical activity guidelines of the Italian Ministry of health, J. Funct. Morphol. Kinesiol 1 (3) (2016) 269–275.

[30] La Sorveglianza PASSI, Rome: National Centre for Epidemiology, Surveillance and Health Promotion (CNESPS) of the Italian National Health Institute (ISS), 2013. Available online: http://www.epicentro.iss.it/parisi/rapporti/2013/Attivita/fitness.aspx. (Accessed 10 June 2020).

[31] V. Giustino, A.M. Parrocco, A. Gennaro, G. Musumeci, A. Palma, G. Battaglia, Physical activity levels and related energy expenditure during COVID-19 quarantine among the Sicilian active population: a cross-sectional online survey study, Sustainability 12 (11) (2020) 4536.

[32] World Health Organization, Global Recommendations on Physical Activity for Health, World Health Organization, Geneva, 2010. https://apps.who.int/iris/bitstream/handle/10665/44399/789241599797-eng.pdf?sequence=1. (Accessed 1 May 2020).

[33] K.C. The, A.R. Aziz, Heart rate, oxygen uptake, and energy cost of ascending and descending the stairs, Med. Sci. Sports Exerc. 34 (4) (2002) 695–699.

[34] C. Davis, M. Cowles, Body image and exercise: a study of relationships and comparisons between physically active men and women, Sex. Roles 25 (1-2) (1991) 33–40.

[35] M. Tiggemann, S. Williamson, The effect of exercise on body satisfaction and self-esteem as a function of gender and age, Sex. Roles 43 (1-2) (2000) 119–127.

[36] M.K. Lusztyk, L. Widman, A.A. Parchane, K.C. Olson, Physical activity and quality of life: assessing the influence of activity frequency, intensity, volume, and motives, Behav. Med. 30 (3) (2004) 124–131.

[37] D. Markland, L. Hardy, The exercise motivations inventory: preliminary development and validity of a measure of individuals’ reasons for participation in regular physical exercise, Per. Indiv. Differ. 15 (3) (1993) 289–296.

[38] W. Li, E. Procter-Gray, L. Churchill, et al., Gender and age differences in levels, types and locations of physical activity among older adults living in car-dependent neighborhoods, J. Frailty Aging 6 (3) (2017) 129–135.

[39] A. van Minnen, L. Hendriks, M. Olff, When do trauma experts choose exposure therapy for PTSD patients? A controlled study of therapist and patient factors, Behav. Res. Ther. 48 (4) (2010) 312–320.

[40] D.J. Crews, D.M. Landers, A meta-analytic review of aerobic fitness and reactivity to psychosocial stressors, Med. Sci. Sports Exerc. 19 (1987) S114–S120.

[41] R.J. Bodnar, G.E. Klein, Endogenous opiates and behavior: 2004, Peptides 26 (12) (2005) 2629–2711.

[42] U. Rimmels, B.C. Zellweger, B. Marti, et al., Trained men show lower cortisol, heart rate and psychological responses to psychosocial stress compared with untrained men, Psychoneuroendocrinology 32 (6) (2007) 627–635.

[43] C. Phillips, Brain-derived neurotrophic factor, depression, and physical activity: making the neuroplastic connection, Neural. Plast. 2017 (2017) 7260130.

[44] Z. Bahadir, A research on the class management behaviors and life satisfaction of physical education teachers, Int. J. Acad. Res. 5 (4) (2013) 170–175.

[45] Z. Pedišić, Z. Greblo, P. Phongsavan, K. Milton, A.E. Bauman, Are total, intensity- and domain-specific physical activity levels associated with life satisfaction among university students? PloS One 10 (2015) e0118137.

[46] K. Busing, C. West, Determining the relationship between physical fitness, gender, and life satisfaction, SAGE Open 6 (4) (2016).

[47] N. Grant, J. Wardle, A. Steptoe, The relationship between life satisfaction and health behavior: a cross-cultural analysis of young adults, Int. J. Behav. Med. 16 (3) (2009) 259–268.

[48] R.P. Joseph, K.E. Royse, T.J. Benitez, D.W. Pekmezic, Physical activity and quality of life among university students: exploring self-efficacy, self-esteem, and affect as potential mediators, Qual. Life Res. 23 (2) (2013) 659–667.

[49] V. Rangul, A. Bauman, T.L. Holmen, K. Midthjell, Is physical activity maintenance better than intervention? An alternative perspective of physical activity interventions, J. Phys. Act. Nutr. Phys. Act. 9 (2012) 144.

[50] I.A. Lesser, C.P. Nienhuis, The impact of COVID-19 on physical activity behavior and well-being of Canadians, Int. J. Environ. Res. Publ. Health 17 (11) (2020) E3899.

[51] T. Loney, M. Standage, D. Thompson, S.J. Sebire, S. Cumming, Self-report vs. objectively assessed physical activity: which is right for public health? J. Phys. Act. Health 8 (2011) 62–70.

[52] M.E. Armstrong, et al., Frequent physical activity may not reduce vascular disease risk as much as moderate activity: large prospective study of women in the United Kingdom, Circulation 131 (2015) 721–729.