

**Exercise improves long-term social and behavioral rhythms in older adults: Did it play a role during the COVID-19 lockdown?**

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**Significance for public health**

The pandemic condition, requiring community containment and social distancing has widely affected the population, especially older adults. However, improvement of social and behavioral rhythms (SBR) in the year before the Covid-19 lockdown were found as an important resilience factor, especially against the risk of depression. Current study suggests that a moderate 12 weeks exercise program improved SBR and that the benefits persisted even after stopping exercise during the Covid-19 lockdown.

**Abstract**

The study aimed to verify whether exercise training in older adults can improve social behavioral rhythms (SBR) and if any modification is maintained over time. Older adults (n=120) from a previous randomized controlled trial (RCT), were randomly allocated to either a moderate-intensity exercise group or a control group. SBR was evaluated at t0, t26, and t48 weeks (during the Covid-19 lockdown), using the brief social rhythms scale (BSRS). Seventy-nine participants completed the follow-up (age 72.3±4.7, women 55.3%). An improvement in the BSRS score was found in the exercise group at 26 weeks (p=0.035) when the exercise program was concluded, and it was still maintained at 48 weeks (p=0.013). No improvements were observed in the control group. To conclude, social behavioral rhythms (SBR), previously found as a resilience factor in older adults during Covid-19, appear to improve after a moderate 12 weeks exercise program, and the improvement persisted even after stopping exercise during the Covid-19 lockdown.

## **Introduction**

Social and behavioral rhythms (SBRs) such as regularity in sleeping, eating, and having social contact are related to metabolic and hormonal circadian rhythms (1). This system is in turn controlled by a complex of pacemakers in which melatonin (2) and cortisol (3) play a central role in responding to external factors such as light/dark cycles (4).

Several experimental results indicate social and behavioral rhythms and circadian rhythms as the key points in the pathophysiology of mood disorders (5) and specifically bipolar disorders (6, 7, 8). Recent work found SBRs to be correlated with a positive perception of the quality of life (QoL) in older adults (9). Indeed, in the same sample, the functionality of SBRs one year before the Covid-19 lockdown was found to be a determinant of resilience against the risk of depressive episodes during the lockdown (10). These results were found in a sample studied during a follow-up at 48 weeks, after a 12-week randomized controlled trial (RCT) on a moderate physical activity program in older adults in which the control group carried out cultural and recreational activities while the active intervention group was subjected to moderate activity (11, 12). The study did not find any association between resilience (13) against depressive episodes during the Covid-19 lockdown and previous physical activity. There was no difference in the frequency of depressive episodes or level of perception of QoL between the group subjected to the experimental physical activity intervention and the control group during the lockdown (10).

There is evidence that physical activity can improve social rhythms and biorhythms (1, 14) as well as perceived physical QoL (15); in our sample, however, resilience to depression during the pandemic was associated with better functioning of social rhythms but not with previous physical activity. A hypothesis to explain this apparent contradiction could be that physical exercise improves social

functioning, but this improvement is not maintained over time and was no longer present in our sample at t48 weeks during the lockdown.

The objective of this study is to verify in the same sample:

- 1) If physical exercise can improve social rhythms (according to previous studies), and
- 2) If any modification is maintained over time.

In this study we wanted to verify if, in our sample of older adults, physical activity could improve social rhythms, and if we could, based on the results, hypothesize why resilience to depression during lockdown at t48 weeks was only associated with a good social rhythm but not with previous physical activity.

## **Methods**

The cohort study was designed as a follow-up of an RCT (11). A total of 120 older individuals were randomly selected (50%=60) to three sessions/week for a 12-week program of moderate-intensity exercise (mixed, aerobic/anaerobic) or (50%=60) to a control protocol of cultural activities. The study was based on mild to moderate exercise to avoid the exclusion of people with chronic but mild medical conditions (such as hypertension or diabetes), which is very common in older adults who live at home. To date, older adults with mild chronic diseases have been routinely excluded from trials that adopt intense levels of physical activity, although these people are among those who could best benefit most from exercise in terms of tertiary prevention. SBRs were evaluated at T26 after the RCT and at 48 weeks participants were contacted and re-evaluated during the first wave of the COVID-19 pandemic.

The outcome measure (functionality of SBRs) was evaluated at t0 and after the trial at t26 and t48 weeks, using the Italian version of the brief social rhythms scale (BSRS) (16, 9). The BSRS is a simplified tool derived from the social rhythm metric (SRM) (17), which is considered too complex for multidimensional evaluations that require time for the collection of data from many tools. The BSRS consists of ten items that assess (ir)regularity in basic daily activities during a week: sleeping (both waking and bedtime), eating (breakfast, lunch, and dinner), and social relationships (at work, school, and leisure time). Participants coded the regularity of each activity on a scale ranging from 1 (strongly regular) to 6 (very irregular). Higher scores indicate higher irregularity. The score is the sum of each item. BSRS has shown excellent psychometric properties in terms of internal consistency in translational studies (16). Differences between pre- (t0 weeks), post- (t26 weeks) and follow-up (t48 weeks) SF-12 scores were measured using one-way ANOVA for repeated measures (considering differences in the entire cohort).

## **Results**

Seventy-nine participants completed the follow-up after 48 weeks and were then evaluated (age  $72.3 \pm 4.7$ , women  $N=42$ , 55.3%). Table 1 summarizes the demographic characteristics of the two study samples, which were balanced by sex, age, and education level. Table 2 shows an improvement in social function measured as a BSRS scale score in the group conducting physical activity. In the experimental group, the improvement was evident at 26 weeks ( $19.56 \pm 7.67$  vs  $22.96 \pm 7.23$ ,  $p=0.035$ ) when the exercise program was concluded, but it was also maintained at 48 weeks ( $19.06 \pm 7.26$  vs  $22.96 \pm 7.23$ ,  $p=0.013$ ). A similar improvement was not recorded in the control group, where the mean BSRS scores remained unchanged in the control group at 26 and 48 weeks compared to the first evaluation. However, the control at T0 weeks of the two experimental and control samples, despite the randomization in blocks that had characterized the study design, showed a difference close to statistical significance concerning the SRBS score ( $22.96 \pm 7.23$  in the exercise group vs  $19.98 \pm 8.28$  in the control group,  $p=0.092$ ). Due to the progressive improvement in functionality (as the SRBS score decreased) in the experimental group and the fact that the mean of the same score remained unchanged in the control group, this difference gradually smooths out at the last evaluation ( $19.06 \pm 7.26$  vs  $18.88 \pm 7.94$ , respectively,  $p=0.575$ ).

## **Discussion**

The study shows that in a sample of older adults who participated in a moderate-intensity aerobic/anaerobic exercise program, the level of social rhythm functionality improved as expected based on the results of previous surveys (1, 14). Well beyond the initial hypothesis, functional improvement was maintained for up to 48 weeks after the active exercise period. A similar improvement was not evident in the control group of older adults who had participated in a cultural entertainment program. The data, therefore, confirmed previously sharpened results, but underlined, for the first time, that the modification of social rhythms induced by physical exercise is maintained for a long time after the program is discontinued. It is further noteworthy that the last study evaluation at 48 weeks was carried out in April 2020, during the lockdown for the Covid-19 pandemic in Italy. These findings are of extreme importance in terms of public health, as the current conditions induced by Covid-19 and the subsequent lockdown have exposed older people to a considerable risk of stress (18, 19). Thus, all factors that could determine resilience to stress should be investigated and studied to provide useful plans for prevention in the future (20). However, a previous analysis of the same study database showed that social functioning in the sample, but not previous physical exercise, was associated with greater resilience to the risk of depression during the Covid-19 lockdown (10). A possible explanation for the conflicting data is that in the study, for apparent randomness, the control sample presented a better social functionality, with a higher mean score in the BSRS scale, to the

limits of the statistically significant difference, compared to the experimental group. Physical exercise induced a statistically significant improvement in social function in the experimental group compared to the baseline SBRS score. However, the final score of the experimental group was perfectly homogeneous with that of the control group.

In conclusion, the new hypothesis is that the initial imbalance prevented any evidence of a difference between the two groups, which probably needed a much larger sample and greater power. This hypothesis cannot be verified in the present sample, which is too small for a multivariate analysis or simple standardization to be performed for the initial SBRS scores. However, it can be evaluated in future studies conducted on appropriate samples concerning foreseeable stressors. In the present study, the Covid-19 stressor was unscheduled, and it was completely coincidental that the last follow-up evaluation was conducted during the lockdown. Evidence that even moderate-intensity exercise can improve social function has an important impact on public health. Physical exercise with these characteristics is accessible and suitable for most elderly people in the social community who suffer from mild medical ailments such as overweight or obesity, hypertension, and diabetes (21, 22).

Social functionality is an important element of resilience to stress and depression. During the Covid-19 pandemic older adults experienced significantly less social contact with friends, relatives, and healthcare workers, an interruption of daily routine activities, poor access to care (including telemedicine), and poor social communication [23]. Moreover, older adults are at the highest risk of death if infected (24). Exercise could improve respiratory performance, allowing for a better chance of survival in the event of Covid-19 infection. An improvement in social rhythm functionality can offer older adults a better sense of control over the Covid-19 threat and, therefore, better coping skills during the pandemic.

### **Limits**

The study sample was very small and the power of the study was limited. The research's main objective was not to measure the link between improved social functioning induced by exercise and resilience during a lockdown since the planning and registration of the trial pre-dated the COVID-19 outbreak and subsequent pandemic.

### **Ethical approval**

The ethical committee of the “Azienda Ospedaliero-Universitaria di Cagliari” approved the study protocol (number PG/2018/15546 of October 25, 2018). The researchers provided information about the study and informed participants about the possibility of discontinuing the interview if they wished. Data were collected in an anonymous database. Each participant provided written informed consent.

The procedures complied with the 1964 Helsinki Declaration and its later amendments.

**Availability of data and material:** The datasets are available only after requests for access directed to project leader Mauro Giovanni Carta as guarantor, according to the agreement shared with the participants and partners, and as stated in the presentation for authorization to the Ethics Committee.

**Competing interest:** The authors declare that they have no competing interests.

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### **Author contribution**

The study was initially designed by MGC and GC, and then discussed with MP, FV, LA, LM, RD, SM, DF, FM, and CIAG. The methodology was decided by MGC, GC, LA, FR, and GC. The MGC conducted the data analysis. The results are collectively discussed. MGC, GC, and drafted the paper or its revisions (FV and LA). All authors read and approved the final manuscript.

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### **References**

1. Haupt S, Eckstein ML, Wolf A, et al. Eat, train, sleep-retreat? Hormonal interactions of intermittent fasting, exercise and circadian rhythm. *Biomolecules* 2021;11:516.
2. Pack W, Hill DD, Wong KY. Melatonin modulates M4-type ganglion-cell photoreceptors. *Neuroscience* 2015;303:178-88.
3. Van Cauter E, Leproult R, Kupfer DJ. Effects of gender and age on the levels and circadian rhythmicity of plasma cortisol. *J Clinl Endocrinol Metab* 1996;81:2468-73.
4. Carta MG, Ouali U, Perra A, et al. Living with bipolar disorder in the time of Covid-19: Biorhythms during the severe lockdown in Cagliari, Italy, and the moderate lockdown in Tunis, Tunisia. *Front Psychiatry* 2021;12:634765.
5. Lieverse R, de Vries R, Hoogendoorn AW, et al. Social support and social rhythm regularity in elderly patients with major depressive disorder. *Am J Geriatr Psychiatry*. 2013;21:1144-53.
6. Liu M, Meng Y, Wei W, Li T. Relationship between circadian rhythm related brain dysfunction and bipolar disorder. *J South Med Univ* 2020;40:822-7.
7. Lopes MC, Boarati MA, Fu IL. Sleep disturbance in bipolar disorder: Neuroglia and circadian rhythms. *Front Psychiatry* 2020;10:1021.

8. Carta MG, Preti A, Akiskal HS. Coping with the new era: Noise and light pollution, Hyperactivity and steroid hormones. Towards an evolutionary view of bipolar disorders. *Clin Pract Epidemiol Ment Health* 2018;14:33-36.
9. Carta MG, Pintus E, Zaccheddu R, et al. Social and behavioral rhythms as a marker of well-being indicator in old adults living at home. *J Clin Med* 2021 (in press).
10. Carta MG, Fornaro M, Cossu G, et al. Social and behavioral rhythms affect resilience to COVID-19-related stress among old adults living at home. *J Affect Disord* 2021 (in press).
11. Carta MG, Cossu G, Pintus E, et al. Active elderly and health-can moderate exercise improve health and wellbeing in older adults? Protocol for a randomized controlled trial. *Trials* 2021;22:331.
12. Carta MG, Cossu G, Pintus E, et al. Moderate exercise improves cognitive function in healthy elderly people: Results of a randomized controlled trial (Active Elderly and Health – ClinicalTrials.gov, NCT03858114). *Clin Pract Epidemiol Ment Health* 2021 (in press).
13. Southwick SM, Bonanno GA, Masten AS, et al. Resilience definitions, theory, and challenges: Interdisciplinary perspectives. *Eur J Psychotraumatol* 2014;5:1.
14. Lee PMY, Huang B, Liao G, et al. Changes in physical activity and rest-activity circadian rhythm among Hong Kong community aged population before and during COVID-19. *BMC Public Health* 2021;21:836.
15. Tocco F, Crisafulli A, Milia R, et al. Nervous facilitation in cardiodynamic response of exercising athletes to superimposed mental tasks: Implications in depressive disorder. *Clin Pract Epidemiol Ment Health* 2015;11:166-73.
16. Margraf J, Lavalley K, Zhang X, Schneider S. Social rhythm and mental health: A. Cross-cultural comparison. *PLoS One* 2016;11:e0150312.
17. Monk TH, Flaherty JF, Frank E, et al. The social rhythm metric. An instrument to quantify the daily rhythms of life. *J Nerv Ment Dis* 1990;178:120-6.
18. Klaiber P, Wen JH, DeLongis A, Sin NL. The ups and downs of daily life during COVID-19: Age differences in affect, stress, and positive events. *J Gerontol B Psychol Sci Soc Sci* 2021;76:e30-7.
19. Carta MG, Romano F, Orrù G. The true challenges of the Covid-19 epidemics: The need for essential levels of care for all. *Open Respir Med J* 2020;14:8-9.
20. Leone MJ, Sigman M, Golombek DA. Effects of lockdown on human sleep and chronotype during the COVID-19 pandemic. *Curr Biol* 2020;30:R930-R931.
21. Fossati C, Torre G, Borrione P, et al. Biohumoral indicators influenced by physical activity in the elderly. *J Clin Med* 2020;9:1115.
22. Velluzzi F, Tocco F, Deledda A, et al. Training impulses: A method to quantify exercise intensity in postmenopausal obese women. 2016 IEEE International Symposium on Medical Measurements and Applications (meMeA). 2016:7533784.
23. Vahia IV, Jeste DV, Reynolds CF 3rd. Older adults and the mental health effects of COVID-19. *JAMA* 2020;324:2253-4.
24. D'Silva KM, Serling-Boyd N, Wallwork R, et al. Clinical characteristics and outcomes of patients with coronavirus disease 2019 (COVID-19) and rheumatic disease: A comparative cohort study from a US "hot spot". *Ann Rheum Dis* 2020;79:1156-62.

Table 1. Characteristics of the sample at the end of the follow-up. Data: counts (%) or mean (standard deviation).

	Active group	Control group	Statistics
	n=44	n=35	
Gender			
Men	21 (50%)	16 (52.1%)	$\chi^2=0.04, p=0.838$
Women	23 (50%)	19 (47.9%)	
Age	72.6 (4.6)	72.2 (4.7)	F (1;103)=0.76, p=0.385
Years of education	14.0 (4.3)	13.1 (4.9)	F (1;103)=2.27, p=0.124

Table 2. Social and behavior function measured using BSRS scores in the two groups (exercise and control) at t0, t<sub>26weeks</sub> and t<sub>48weeks</sub>

	T0 t <sub>0weeks</sub> c Score EG	T <sub>26weeks</sub> BSRS score EG	T <sub>48weeks</sub> BSRS score CG	T0 vs T <sub>26weeks</sub>	T0 vs T <sub>48weeks</sub>
Exercise group (n=44)	22.96±7.23	19.56±7.67	19.06±7.26	DF=1,87 F=4.591 p=0.035	DF=1,87 F=6.375 p=0.013
Control group (n=35)	19.98±8.28	20.53±8.98	18.88±7.94	DF=1,69 F=0.071 p=0.791	
	Exercise vs control DF=1,78 F=2.911 p=0.092	Exercise vs control DF=1,78 F=0.071 p=0.0791	Exercise vs control DF=1,78 F=0.322 p=0.575		