Exercise Effect on Mental Health in Isolating or Quarantining Adults

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INTRODUCTION: In response to coronavirus disease 2019 (COVID-19), travelers are typically subject to quarantine, which is often associated with poorer mental health (MH). While the protective benefits of community-based exercise are widely recognized, the degree to which this extends to the confined setting is unknown. This systematic review aims to evaluate the effect of exercise on MH in isolating or quarantining adults.

- **METHODS:** A literature search of Ovid MEDLINE, APA PsycInfo, and the Cochrane Database of Systematic Reviews limited to January 2019–September 2021 inclusive yielded five eligible studies.
- **RESULTS:** Data comprised a total of 2755 college and university students, most of whom were confined. Depending on the scale used, 24.9–76.7% of respondents demonstrated impaired MH, which improved with physical activity (PA), especially when regular and moderate or vigorous. The frequency, duration, and participants of exercise increased as lockdown progressed. One study showed that while sleep, diet, and PA all have an impact on MH, PA was the factor most strongly correlated with MH.
- **DISCUSSION:** Physical fitness should be optimized before and maintained during quarantine while exercise space and equipment should be accessible. Importantly, the sustainability of persistent quarantine must be considered given the pervasiveness of COVID-19.
- **KEYWORDS:** air travel, COVID-19, lockdown, depression, anxiety, stress, mood, well-being, physical activity.

Chu V, Newman DG. Exercise effect on mental health in isolating or quarantining adults. Aerosp Med Hum Perform. 2023; 94(9):686–695.

n March 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) a pandemic.²⁴ Globally, 226.8 million cases, including 4.7 million deaths, were reported as of 17 September 2021,⁸⁹ the direct and indirect costs estimated at 16 trillion USD.²⁵ Balancing health costs against economic costs, government responses varied widely, fluctuating over the course of the outbreak. The Stringency Index records out of 100 the strictness of policies that primarily restrict people's behaviors. On 18 March 2020, this ranged from 0 in Dominica (no restrictions) to 100 in Jordan (nationwide curfew).⁸¹ Absent definitive treatment, nonpharmaceutical interventions such as hand hygiene, personal protective equipment, and physical distancing became the mainstay.49 COVID-19 cannot be differentiated from influenza based on symptomology alone. COVID-19's incubation period ranges from 2.33 to 17.60 d, with the average of 6.38 increasing 1 d per decade in the elderly.^{30,66} Thus, travelers are subject to control measures such as travel restrictions, border screening, and quarantine,¹³ typically 14 d, sometimes longer.⁸⁰ Pursuant to the Australian Biosecurity Act,⁹ leaving isolation or quarantine without permission except under exigent circumstances is a criminal offense liable to imprisonment and a fine. Food and medication must be delivered since visiting public places is prohibited,^{7,8} effectively restricting Maslow's Hierarchy of Needs⁶⁰ to the bottom two tiers (**Fig. 1**).⁶⁸ Failing to fulfill the first three tiers may contribute to suicidal ideation when "psychache," a cognitive state of mental torment or "constriction," reaches a limit and no effective methods are

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This manuscript was received for review in February 2022. It was accepted for publication in June 2023.

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Fig. 1. Maslow's Hierarchy of Needs. Maslow theorized that basic human needs are prioritized in an ascending hierarchy, such that a "higher" need will not be pursued unless the "lower" need is met.⁶⁰

identified to reduce it.⁴⁰ Indeed, being quarantined is associated with anxiety, depression, and suicidality,^{35,50,90} the first two significantly worsening with stricter restrictions.⁶⁹ Poor mental health (MH) is a leading cause of disability globally and negatively impacts productivity⁵⁸ and gross domestic product^{32,71} to the extent that workplace interventions like education programs, cognitive behavioral therapy, and physical exercise have been trialed extensively.⁷⁴

While there are multiple factors that contribute to MH, sleep is an important one. Adequate hours of sleep and good quality of sleep are important in promoting general well-being and health, and insomnia and sleep disturbances have been linked to poor MH outcomes.^{2,56,75} Inadequate sleep, insomnia, and changes in sleep onset times due to circadian dysrhythmia are frequent issues in those who travel,^{14,15} especially aircrew crossing multiple time zones.^{21,86} Several studies have shown that physical activity (PA) can improve sleep quality and therefore lead to improved MH.^{37,78,79}

WHO ranks physical inactivity fourth in risk factors for mortality, after hypertension, smoking, and diabetes.⁸⁸ Exercise provides many biopsychosocial benefits, including improved functional capacity, mood states, improved sleep quality, and quality of life.⁶⁴ Up to recommended levels, exercise and mental well-being are positively correlated.²⁹ Rather than a neutral effect, sedentary behavior and mental illness are positively correlated.⁹² While research consistently indicates a relationship between exercise and depression, the mechanism remains unclear.²³ Several, such as the thermogenic, endorphin, monoamine, distraction, and self-efficacy hypotheses, have been proposed, but not universally accepted.²³

The American Heart Association recommends that adults undergo an equivalent of at least 150 min of moderate or 75 min of vigorous aerobic activity per week, with more benefits derived from at least 300 min of activity weekly. Further, muscle-strengthening activity of moderate-to-high intensity should be added at least 2 d/wk.⁵ Meeting these targets under confinement may be impractical for most aircrew and passengers given the limited access to space and equipment. Indeed, significantly decreased levels of PA in the community and those under confinement have been reported in many nations since the pandemic. Internationally, mean step count decreased 27.3%,⁷⁶ vigorous PA decreased 42.2%,⁸⁵ and sedentary time increased 23.8%.¹⁷ Nonetheless, the aforementioned consequences of nonadherence may outlast the quarantine period,⁵⁰ yet some populations such as aircrew are subject to repetitive cycles of quarantine.

The International Air Transport Association's (IATA) forecasted recovery of the aviation industry has been delayed to 2024,⁴⁵ complicated by mutating variants of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Since 83% of passengers are reluctant to undergo 14 d of isolation,⁴⁶ air travel demand reduced 65.9%.43 Because Available Seat-Kilometers and the associated passenger belly freight plummeted, Cargo Ton-Kilometers reached a record high,⁴² led by freighter airlines such as Federal Express and United Parcel Service,⁴³ straining freighter pilots in particular.³⁸ Notably, some Cathay Pacific crew operate 21-d "closed-loop" patterns followed by 14 d of quarantine.²⁶ In 2015, an Airbus A320 carrying 150 persons was intentionally flown into the French Alps by the copilot of Germanwings flight 9525, who had a history of severe depression with possible psychosis.33 This fatal accident reminded stakeholders that mental illness among flight crews, if undetected, can lead to catastrophic outcomes, prompting the European Aviation Safety Agency to recommend an Action Plan that includes improved psychological evaluations, psychoactive substances testing, and peer support programs.³¹

This systematic review aims to evaluate the effect of exercise on MH in isolating or quarantining adults. To the authors' knowledge, while some have studied the relationship between PA and mental well-being during the pandemic,^{82,87} few have focused on individuals confined under isolation or quarantine. A recent review made recommendations on how to reduce the psychological impact of quarantine, but exercise was not mentioned.¹²

METHODS

Articles sought include primary experimental and observational studies examining associations between PA and MH in adults confined under isolation or quarantine. Randomized control trials were preferred, although other study designs such as cohort, case-control, and cross-sectional studies were considered. Literature reviews, systematic reviews, and communiques such as editorials, commentaries, and letters were excluded.

Subjects included adults up to 64 yr of age inclusive [within 1 SD or interquartile range (IQR) unless the range is explicitly reported] to better match both the traveling public and aircrew. The upper age limit for professional pilots in multicrew aircraft is 65.⁴⁷ Subjects were isolated or quarantined, regardless of location, without access to outdoor PA. While both are public health practices involving segregation, isolation is for confirmed cases of COVID-19 and quarantine is for potential cases.¹⁸ For the purposes of this review, both terms can be used interchangeably. Unless confinement parameters are explicitly

defined, the Oxford COVID-19 Government Response Tracker (OxCGRT) will be cross-referenced for Stay At Home Requirements,⁶² where Total Confinement is coded as 3.⁶¹ Studies focusing on the elderly, pregnant, or specific comorbidities were excluded to discourage the confounding effect of risk factors known to be occasionally associated with impaired MH.

PA is defined as any bodily movement generated by the musculoskeletal system requiring energy exertion that is purposeful, structured, and repetitious, with the primary objective of improving or maintaining physical fitness.¹⁶ Aerobic exercise such as low-intensity steady-state or highintensity interval training and resistance training with bands, body weight, or free weights are examples that satisfy this definition. Provided it can be performed during isolation or quarantine, it was considered regardless of type, intensity, duration, or frequency and whether dedicated equipment was required. For the purposes of this study, the presence or absence of exercise was more important than the specifics of exercise. The comparator was physical inactivity, which may include sedentary behaviors such as watching television. Ideally, only studies using standardized measurement scales such as the International Physical Activity Questionnaire (IPAQ) were included, but due to the paucity of data, nonstandardized responses were also considered.

Per evidence-based principles, MH should be measured by a published scale to minimize measurement bias, encourage standardization, and improve comparability. Across some 65 unique instruments largely suitable for the general, nonclinical adult population, the commonest endpoints are depression, anxiety, and distress,¹¹ which formed the foundation of the search strategy. Most of the 65 instruments are self-administered, which is conducive to minimizing unnecessary clinical contact in observance of physical distancing directives. Few of these 65 instruments require specific training prior to use, which will facilitate recruitment and response rates. An example of a practical instrument is the Patient Health Questionnaire-9 (PHQ-9), which exhibits generally good psychometric properties such as construct validity, criterion validity, internal consistency, and test-retest reliability.¹¹

An advanced search was conducted on 12 September 2021 in Ovid MEDLINE (1946 to 10 September 2021), APA PsycInfo (1806 to September Week 1, 2021), and the Cochrane Database of Systematic Reviews (2005 to 9 September 2021) using the following medical subject heading terms and keywords:

- Quarantine/OR quarantin*.mp. OR (Patient Isolation/OR isolat*.mp.); AND
- Exercise/OR Exercise Therapy/OR exercis*.mp.; AND
- Mental Health/OR Psychological Distress/OR Stress, Psychological/OR Anxiety.mp. OR Depression/OR (Mood Disorders/OR mood.mp.).

Results were limited to human studies published in English from 2019 to 2021 inclusive to capture potential studies from the first COVID-19 case to the time of writing then deduplicated with the integrated function in descending preference of Ovid MEDLINE, APA PsycInfo, and then the Cochrane

Table	I.	Inclusion	and	Exclusion	Criteria.

INCLUSION	EXCLUSION
Primary studies.	Secondary studies.
Published in English from 1 January 2019 to 12 September 2021 inclusive.	Irretrievable studies.
Subjects ages 18 to 64 inclusive (within one SD or IQR unless range explicitly reported).	Studies focusing on subjects who are pregnant or with specific comorbidities.
Addresses PA, MH with validated scales, and isolation or quarantine (± subgroup analysis).	

PA: physical activity; MH: mental health.

Database of Systematic Reviews. Results were exported as a text file.

Per the inclusion and exclusion criteria presented in **Table I**, both authors independently screened the studies by title, abstract, and index terms. The remainder and any equivocal studies were fully examined for eligibility. Studies applying nonprobability sampling were included provided subgroup analysis was performed.

The Mixed Methods Appraisal Tool (MMAT)³⁹ was used as the critical appraisal tool because of its efficiency and reliability in assessing quality and bias in qualitative and quantitative evidence.⁶³ Meta-analysis was not performed due to the heterogeneity and restricted number of studies included in this preliminary review.

RESULTS

Identified were 241 potentially relevant studies; 27 duplicates were removed and 135 records were excluded at the screening stage. Of the 79 examined, 74 were excluded because of age (N = 33), confinement status (N = 22), study type (N = 13), disqualifying condition (N = 4), and other reasons (N = 2; absence of exercise intervention and subgroup analysis), leaving 5 studies that met the criteria (see **Table II**). A flowchart of the selection process is provided in **Fig. 2**.

The included studies were separately analyzed then summarized in Table II. Two are cohort studies^{3,34} and three are cross-sectional studies^{52,53,67}; experimental studies were lacking. Two were conducted in Spain,^{34,67} one in Italy,³ one in Bangladesh,⁵² and one in the Middle East and North Africa region.⁵³ Two studies applied convenience sampling,^{3,52} one snowball sampling,⁵³ and two expanded on prior studies.^{34,67} Data were collected online in all studies, which comprised a total of 2755 college and university students, 1397 men and 1358 women, most of whom were confined in the context of COVID-19.

Two studies reported significantly increased frequency or duration of exercise as lockdown progressed,^{34,67} one of which reported an increase in the number of exercisers.³⁴ The median hours of PA per week were two before lockdown, three after 10 d (P = 0.072), and four after 40 d (P < 0.001).³⁴ One study reported significantly increased PA and sitting time regardless of feelings of anxiety or depression.⁶⁷

Table II. Summary of Included Studies.

REFERENCE	DESIGN	SUBJECTS	INTERVENTION	OUTCOME	FINDINGS
Amatori et al., Italy ³	Cohort study	176 male (92) and female (84) college students ages 23 ± 4 yr under home isolation for entire 3 wk (except 7 subjects).	Exercise in the form of indoor walks, runs, rides, skipping, or free-weight exercises 4.6±3.3 times/wk; mean duration 54±41 min; RPE 6.6±1.8 as measured by modified CR-10.	Respectively, men and women scored a median of 31 and 27 for PANAS+, 18 and 23 for PANAS-, 6 and 7 for PHQ-9, and 39 and 37 for SF-12; 76.7% reported mild-to-severe depression as measured by PHQ-9.	At 21 d, exercise partially mediated the relationship between PANAS, PHQ-9, SF-12, and fruit, vegetable, and fish consumption ($P < 0.05$), counterbalancing the impact of negative psychological states on dietary habits.
Gallego-Gómez et al., Spain ³⁴	Cohort study	138 male (30) and female (108) nursing students with a median age of 20 yr (IQR 19–23), home-bound.	Exercise duration and number of exercisers increased significantly as lockdown progressed (P < 0.001).	Median SSI-SM scores were 40 (IQR 30.8–48.3) before lockdown, 41 (IQR 33.0–51.0) at 10 d (P = 0.001), and 41 (IQR 34.8–49.0) at 40 d (P = 0.004).	At 40 d, students exercising regularly reported significantly lower stress levels (39, IQR 32.0–48.0) than their counterparts (45, IQR 38.0–56.0) (<i>P</i> = 0.014). Differences were not significant at 10 d or before lockdown.
Khan et al., Bangladesh ⁵²	Cross-sectional study over 15 d inclusive	505 male (317) and female (188) college and university students ages predominantly 20–24 yr under home quarantine.	26.73% reported exercising during quarantine.	46.92% reported depression, 33.28% anxiety, and 28.50% stress as measured by DASS-21; 69.31% reported ESD as measured by IES, worse in university students.	Exercise was significantly associated with lower scores of depression subscale ($B = -2.10, 95\%$ Cl: -4.02 to -0.17)
Kilani et al., Middle East and North Africa ⁵³	Cross-sectional study over 55 d inclusive	1723 male (917) and female (806) university members ages 34.9 ± 12.8 yr under home confinement.	PA (MET-min/wk) stratified as low, moderate, or high as measured by IPAQ-SF.	32.6% reported poor mental well-being as measured by WHO-5.	Mental well-being showed a dose-response relationship with PA, especially when moderate or vigorous (P < 0.001). Between sleep, diet, and PA, the latter was by far the major determinant of MH.
Romero-Blanco et al., Spain ⁶⁷	Cross-sectional study over 63–92 d inclusive	213 male (41) and female (172) health sciences students ages 20.5 ± 4.56 yr under lockdown.	Especially for female and non-overweight students, duration and frequency of PA significantly increased during lockdown as measured by IPAQ-SF ($P < 0.001$). Sitting time increased significantly in most groups ($P < 0.001$).	24.9% reported feelings of anxiety/depression as measured by EQ-5D.	PA and sitting time increased regardless of feelings of anxiety/depression. Students reporting feelings of anxiety/depression exercised more than their counterparts. Students on a Mediterranean diet exercised more than their counterparts.

B: beta; CI: confidence interval; CR-10: Category-Ratio 10; ESD: event-specific distress; MET: metabolic equivalent of task; RPE: Borg Rating of Perceived Exertion; PANAS: Positive and Negative Affect Schedule; PHQ-9: Patient Health Questionnaire-9; SF-12: Short Form-12; IQR: interquartile range; SSI-SM: Student Stress Inventory-Stress Manifestations; DASS-21: Depression Anxiety Stress Scale-21; IES: Impact of Events Scale; PA: physical activity; IPAQ-SF: International Physical Activity Questionnaire-Short Form; EQ-5D: EuroQol 5-Dimension.

Impaired MH was reported by 24.9–76.7% of respondents depending on the study and the scale used: Positive and Negative Affect Schedule (PANAS), PHQ-9, Short Form-12 (SF-12), Student Stress Inventory-Stress Manifestations (SSI-SM), Depression Anxiety Stress Scale-21 (DASS-21), Impact of Events Scale (IES), WHO-5 Wellbeing Index (WHO-5), or EuroQol 5-Dimension (EQ-5D). The scales are summarized in **Table III**.

One study examined PA and MH separately and did not directly analyze the relationship between them.³ Three studies showed that improved MH is significantly associated with PA,^{34,52,53} especially when regular³⁴ and moderate or vigorous (**Fig. 3**).⁵³ One study showed that subjects reporting feelings of anxiety or depression exercised more than their counterparts; the authors attribute this to the subjects' health sciences



Fig. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

background, although causation could not be established due to the study design.⁶⁷

In a study by Kilani et al., MH was found to be affected by several factors (diet, sleep, and PA).⁵³ Sleep quality was strongly associated with MH and a balanced diet with good quality food was linked with enhanced MH. However, the study found that PA was the best predictor of MH, and that it had a much greater impact on MH than either sleep or diet (beta = 0.348, P < 0.001, r = 0.427). Other regression analyses indicate that a change in PA is the best single predictor of a change in MH.^{54,77} Additionally, PA may act as a partial mediator between diet and mood, particularly via fruit, vegetable, and fish consumption.³ Higher PANAS positive scores were associated with higher intake of cereals, legumes, and lean meats.³ Students on a Mediterranean diet exercised more than their counterparts.⁶⁷ Thus, the relationship between mood, exercise, and diet may be illustrated by **Fig. 4**.

Table IV shows the criteria and summary of MMAT. All the studies are categorized as quantitative nonrandomized studies. Collected data appropriately addressed their clearly defined research questions. Tertiary students are not necessarily representative of the traveling public and aircrew. All studies measured MH with standardized scales; two studies did not measure PA with a standardized scale.^{34,52} In Amatori et al.'s study,³ all but seven subjects spent the entire lockdown in their residences.

DISCUSSION

Stress is a normal response to a stressor, whether actual or perceived.⁷⁰ While mental well-being is multifaceted, influenced by factors such as socioeconomic status, education level, and psychological support,⁵⁷ PA seems to play a major

mitigating role.⁵³ While the anxiolytic and antidepressant effects of community-based exercise are widely recognized, this review shows that those benefits appear to extend to the confined setting. Incidentally, not only is exercise associated with improved mood, it is also associated with improved dietary habits. A recent systematic review concluded that certain diets could improve mood.⁶ Thus, associations are observed between exercise, mood, and diet (Fig. 4).

The American College of Sports Medicine provided recommendations on how to remain active during COVID-19.⁴ Yoga, calisthenics, and dancing are examples of suggested activities. However, given the dose-response relationship (Fig. 3),⁵³ moderate and vigorous PA may be difficult to achieve without dedicated space or equipment. Practical solutions include provision of rental exercise bikes in hotel rooms²⁸ or bringing a skipping rope⁵ or resistance bands.⁵⁹ The routine should comprise aerobic, strengthening, and stretching components.⁷³ App- or web-based programs are useful adjuncts, subject to personal preference and technical proficiency.^{4,27}

Some subjects may proactively buffer the anticipated impact of lockdowns by changing their lifestyle in the form of increased exercise and modified diets.³ Indeed, this should occur long before confinement, as the positive effects of PA on MH continue beyond the cessation of exercise.⁷² One study found that athletes scored better in DASS-21 and IES scales compared to nonathletes, despite at least a 2-mo break in training due to home isolation.⁷² Likewise, individuals identifying as healthier had higher mental well-being scores, even under confinement.⁵³ It is worth emphasizing that, in Romero-Blanco et al.'s study, students on a Mediterranean diet and those not overweight exercised more than their counterparts, suggesting that individuals who lead a healthy lifestyle tend to persist with their

SCALE	RANKING	SCORE
PANAS ³		
Affect	Positive (+) Negative (–)	Range 10–50 Range 10–50
PHQ-9 ³	-	
Depression	None Mild Moderate Moderately severe Severe	0-4 5-9 10-14 15-19 >20
SF-12 ³		
Physical health	Physical component summary	Range 10–70
Mental health	Mental component summary	Range 6–72
SSI-SM ³⁴		
Stress		Total out of 95
DASS-21 ⁵²		
Depression	Normal Mild Moderate Severe	0-9 10-13 14-20 21-21
Anxiety	Normal Mild Moderate Severe	0-7 8-9 10-14 15-19
Stress	Normal Mild Moderate Severe	0-14 15-18 19-25 26-33
IES ⁵²		
Event-specific distress	Subclinical Mild Moderate Severe	0-8 9-25 26-43 ≥44
WHO-553		
Mental well- being EQ-5D ⁶⁷	Poor Good	≤13 >13
Quality of life		Response other than "I am not anxious or depressed" is positive for anxiety or depression symptoms

PANAS: Positive and Negative Affect Schedule; PHQ-9: Patient Health Questionnaire-9; SF-12: Short Form-12; SSI-SM: Student Stress Inventory-Stress Manifestations; DASS-21: Depression Anxiety Stress Scale-21; IES: Impact of Events Scale; WHO-5: WHO-5 Wellbeing Index; EQ-5D: EuroQol 5-Dimension.

habits regardless of their environment.⁶⁷ Gallego-Gómez et al. found that while exercise made no significant difference to stress levels before lockdown, significant improvements were observed as lockdown progressed.³⁴ Thus, physical fitness should be optimized before and maintained during quarantine. Because the primary outcomes of interest are PA and MH, cross-cultural differences were not considered. Likewise, data on cultural or religious adjustments of PA or MH scales are limited and were therefore not examined.⁵⁵

Accordingly, exercise space and equipment should be accessible to isolating or quarantining individuals, not just for cardiovascular health, but for MH as well, since the presence of an exercise environment is a potential source of fitness



Fig. 3. Mental well-being stratified by PA levels. High PA (18.2 ± 2.5) showed a significantly higher overall WHO-5 score than moderate (17.0 ± 2.8; P < 0.001) and low PA (12.9 ± 3.7; P < 0.001).⁵³

motivation.⁵¹ As Gallego-Gómez and Romero-Blanco et al. found, the duration or frequency of exercise and the number of exercisers increased as lockdown progressed.^{34,67} A 2020 study of 13,696 respondents modeled that those who rarely exercise before a lockdown tend to increase their exercise frequency, and those who are frequent exercisers before a lockdown tend to maintain it,¹⁰ so lockdowns appear to create a demand for exercise. Optionally, individuals may bring their own portable equipment, since even light activity can offset some of the risks of sedentary behavior.⁵ Just as importantly, healthy food options should also be available due to their mood-regulating effects.⁶ These efforts may improve the perception of quarantine and, by extension, the number of passengers willing to undergo isolation, thereby helping to restart the aviation industry.

Effective as PA may be, the root cause that is quarantine ought to be addressed. The status quo may no longer be justifiable 2 yr on, as SARS-CoV-2 has become widespread. In a poll conducted by Nature, nearly 90% of international experts think that COVID-19 will eventually become endemic, not unlike influenza, likely requiring annual vaccination.⁶⁵ As progress is made on definitive treatment, antigen testing, and herd immunity, IATA proposed alternatives that rely less on quarantine yet still reduce the risk of imported cases via travelers and mitigate risk in cases where an infected person does travel.⁴⁴ Border restrictions and extended quarantine yield diminishing returns as the pandemic evolves, especially where epidemics are not controlled at its source.^{19,36} Retrospective data from Bahrain shows that only 0.2-0.6% of air travelers tested positive during quarantine compared to 2.1-2.6% community transmission in the same period.¹ Depending on the setting, mass 14-d quarantine can be relaxed,^{1,91} taking into account incidence gradients^{83,91} as robust local control is at least as likely to reduce viral



Fig. 4. Associations between exercise, mood, and diet. Exercise directly and indirectly improves mood.^{3,67}

Table IV. Risk of Bias Assessment Using MMAT.³⁹

QUESTION	AMATORI ET AL. ³	GALLEGO-GÓMEZ ET AL. ³⁴	KHAN ET AL. ⁵²	KILANI ET AL. ⁵³	ROMERO-BLANCO ET AL. ⁶⁷
Are there clear research questions?	Yes	Yes	Yes	Yes	Yes
Do the collected data address the research questions?	Yes	Yes	Yes	Yes	Yes
Are the subjects representative of the target population?	No	No	No	No	No
Are measurements appropriate regarding both the outcome and intervention (or exposure)?	Yes	Yes	Yes	Yes	Yes
Are there complete outcome data?	Yes	Yes	Yes	Yes	Yes
Are the confounders accounted for in the design and analysis?	Yes	Yes	Yes	Yes	Yes
During the study period, is the intervention administered (or exposure occurred) as intended?	Yes	Yes	Yes	Yes	Yes

MMAT: Mixed Methods Appraisal Tool.

transmission.^{20,22} Updated recommendations from the International Civil Aviation Organization include exempting immunized individuals, especially crew, from testing and quarantine, subject to risk assessment.⁴⁸

This review has several limitations. Only five studies were included due to the novelty of COVID-19 and the paucity of literature relating PA and MH in quarantine, reflecting the limited data available at the time. More studies and larger samples would provide more statistical power. Because cross-sectional studies demonstrate association but not causation, experimental studies, particularly randomized control trials, would be beneficial. However, this may raise ethical concerns given the strong body of evidence linking PA and MH. In contrast, an advantage of cohort studies is that temporality of exposure and outcome can be established. Recall bias is possible, although this is likely minimized by daily diary entries as was the case in Amatori et al.'s study.³ Online questionnaires require internet access, which may be available only to respondents from a higher socioeconomic background in some countries. This, together with nonprobability sampling, introduces selection bias.

Isolation, quarantine, and lockdowns are variably defined and enforced across different jurisdictions,⁶² so heterogeneity of confinement status is possible, potentially confounding the findings. A study of around 42,000 Brazilians showed only 73.5–77.0% adhered to quarantine directives,⁸⁴ which is relevant as psychological distress is associated with reduced access to outside or green space.⁴¹ Subnational data was not always available for cross-referencing in the OxCGRT where studies did not explicitly define confinement parameters, potentially affecting screening and eligibility.

Aircrew and passengers are groups frequently subject to isolation or quarantine. While the study was designed to match both, relevant studies focusing on the target populations were lacking. Though the studies demonstrated high internal validity, external validity may be improved by including studies focusing on aircrew and passengers. For instance, students are generally younger, may come from contrasting socioeconomic backgrounds, and experience different (e.g., academic) stressors, potentially skewing the results. There were 33 studies excluded because of invalid age, so a broader dataset may be available by relaxing age criteria.

In conclusion, PA appears to be a major, if not the strongest correlate, of MH for isolating or quarantining adults and, therefore, should be optimized before and maintained during confinement. Many cost-effective, practical solutions are available and should be accessible during isolation or quarantine. Other factors known to have an effect on MH, such as sufficient sleep and good nutrition, should not be neglected as part of a holistic approach. While effective, the sustainability of persistent quarantine must be considered. More experimental studies, especially those of aircrew and passengers, are encouraged.

ACKNOWLEDGMENTS

Dr. Vichai Chu would like to thank the teaching staff of The School of Public Health and Preventive Medicine at Monash University for their technical and supporting role in this systematic review.

Financial Disclosure Statement: Dr. Chu is a commercial pilot at an international airline. Dr. Newman has no competing interests to declare.

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