**Abstract 169**

**Manuscript 3080**

**Figures 1**

**Tables 4**

**References 53**

**eFigures 0**

**eTables 1**

**Physical activity, suicidal ideation, suicide attempt and death among individuals with mental or other medical disorders: a systematic review of observational studies**

**Authors**: Nicholas Fabiano MD1\*, Arnav Gupta MD2,3\*, Stanley Wong MD4, Jason Tran MD4, Ibrahim YZ Mohammad MD4, Shan Bal BHSc5, Jess G Fiedorowicz MD PhD1,6,7,8, Joseph Firth PhD9,10, Brendon Stubbs PhD MCSP11,12, Davy Vancampfort PT PhD13, Felipe B Schuch PhD14,15,, Lucas J Carr PhD16, Risa Shorr MLS17, Samuele Cortese MD PhD18,19, Mirko Manchia MD PhD20,21,22, Catharina A Hartman PhD43, Anne Høye MD PhD23,24, Paolo Fusar-Poli MD PhD25,26,27,28, Ai Koyanagi MD PhD29,30,31, Eduard Vieta MD PhD32, René Ernst Nielsen MD PhD33,34, Richard IG Holt PhD FRCP35,36 Christoph U Correll MD37,38,39, Ebba Du Rietz PhD40, Heidi Taipale PhD41,42 , Kelli Lehto PhD44, Henrik Larrson PhD45 , Merete Nordentoft MD PhD46, Elena Dragioti PhD47,48, Karolina Skonieczna-Żydecka PhD49 & Marco Solmi MD PhD1,6,7,8,37 on behalf of the ECNP Physical And meNtal (PAN-)Health group

Nicholas Fabiano and Arnav Gupta contributed equally to this paper.\*

1. Department of Psychiatry, University of Ottawa, Ottawa, ON, Canada
2. Department of Medicine, University of Calgary, Calgary, AB, Canada
3. College of Public Health, Kent State University, Kent OH, United States
4. Department of Psychiatry, University of Toronto, Toronto, ON, Canada
5. Faculty of Health Sciences, McMaster University, Hamilton, ON, Canada
6. Department of Mental Health, The Ottawa Hospital, Ottawa, ON, Canada
7. Ottawa Hospital Research Institute (OHRI) Clinical Epidemiology Program, University of Ottawa, Ottawa, ON, Canada
8. School of Epidemiology and Public Health, Faculty of Medicine, University of Ottawa, Ottawa, ON, Canada
9. Division of Psychology and Mental Health, University of Manchester, Manchester Academic Health Science Centre, Manchester, UK
10. Greater Manchester Mental Health NHS Foundation Trust, Manchester Academic Health Science Centre, Manchester, UK
11. EXI, People’s Mission Hall, Whitechapel Road, London, UK
12. Department of Psychological Medicine, Institute of Psychiatry, Psychology and Neuroscience, Kings College London, London, UK.
13. KU Leuven Department of Rehabilitation Sciences, Leuven, Belgium
14. Department of Sports Methods and Techniques, Federal University of Santa Maria, Santa Maria Brazil
15. Faculty of Health Sciences, Universidad Autónoma de Chile, Providencia, Chile
16. Department of Health and Human Physiology, University of Iowa, Iowa City, IA, United States
17. Library Services, The Ottawa Hospital, Ottawa, ON, Canada
18. Centre for Innovation in Mental Health, University of Southampton, Southampton, UK
19. Solent NHS Trust, Southampton, UK
20. Unit of Psychiatry, Department of Medical Sciences and Public Health, University of Cagliari, 09124 Cagliari, Italy
21. Unit of Clinical Psychiatry, University Hospital Agency of Cagliari, 09124 Cagliari, Italy
22. Department of Pharmacology, Dalhousie University, Halifax, NS B3H 4R2, Canada
23. Department of Psychiatry, UiT The Arctic University of Norway, Tromsø, Norway
24. Division of Mental Health and Substance Abuse, University Hospital of North Norway, Tromsø, Norway
25. Early Psychosis: Interventions and Clinical-detection (EPIC) Lab, Department of Psychosis Studies, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, United Kingdom
26. OASIS service, South London and Maudsley NHS Foundation Trust, London, United Kingdom
27. Department of Brain and Behavioral Sciences, University of Pavia, Pavia, Italy
28. National Institute for Health Research Maudsley Biomedical Research Centre, South London and Maudsley NHS Foundation Trust, London, United Kingdom
29. Research and Development Unit, Parc Sanitari Sant Joan de Deu, CIBERSAM, Sant Boi de Llobregat, Barcelona, Spain
30. Catalan Institution for Research and Advanced Studies, Barcelona, Spain
31. Centro de Investigación Biomédica en Red de Salud Mental, Madrid, Spain
32. Hospital Clinic, Institute of Neuroscience, University of Barcelona, IDIBAPS, CIBERSAM, Barcelona, Catalonia, Spain
33. Aalborg University Hospital, Department of Psychiatry, Aalborg, Denmark
34. Aalborg University, Aalborg, Denmark
35. Human Development and Health, Faculty of Medicine, University of Southampton, UK
36. Southampton National Institute for Health Research Biomedical Research Centre, University Hospital Southampton NHS Foundation Trust, Southampton, UK
37. Charité - Universitätsmedizin Berlin, Department of Child and Adolescent Psychiatry, Berlin, Germany
38. The Zucker Hillside Hospital, Department of Psychiatry, Northwell Health, Glen Oaks, NY, USA
39. Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Department of Psychiatry and Molecular Medicine, Hempstead, NY, USA
40. Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden
41. Department of Forensic Psychiatry, University of Eastern Finland, Niuvanniemi Hospital, Kuopio, Finland
42. Department of Clinical Neuroscience, Division of Insurance Medicine, Karolinska Institutet, Stockholm, Sweden
43. Department of Psychiatry, Interdisciplinary Center Psychopathology and Emotion regulation(ICPE) University Medical Center Groningen, University of Groningen, The Netherlands.
44. Estonian Genome Centre, Institute of Genomics, University of Tartu, Tartu, Estonia
45. Department of Medical Sciences, Örebro Universitet, Örebro, Sweden
46. Core-Copenhagen Research Center for Mental Health, Copenhagen University Hospital, Denmark
47. Research Laboratory of Psychology of Patients, Families & Health Professionals, Department of Nursing, School of Health Sciences, University of Ioannina, 45500 Ioannina, Greece
48. Pain and Rehabilitation Centre and Department of Medical and Health Sciences, Linköping University, 581 85, Linköping, Sweden
49. Department of Biochemical Research, Pomeranian Medical University in Szczecin, Sczczecin, Poland

Marco Solmi (Corresponding author): msolmi@toh.ca

Funding sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclosures: MS received honoraria/has been a consultant for Angelini, Lundbeck, Otsuka. NF, AG, SW, JT, IM, SB, KL and JGF have no conflicts of interest to declare. JF is supported by a University of Manchester Presidential Fellowship (P123958) and a UK Research and Innovation Future Leaders Fellowship (MR/T021780/1) and has received honoraria / consultancy fees from Atheneum, Informa, Gillian Kenny Associates, Big Health, Nutritional Medicine Institute, ParachuteBH, Richmond Foundation and Nirakara, independent of this work. Brendon Stubbs holds an NIHR Advanced fellowship (NIHR301206, 2021-2026).  Brendon is local PI lead on exercise intervention trials unrelated to the paper 1) NIHR: Supporting Physical and Activity through Co-production in people with Severe Mental Illness (SPACES,2021-2027); 2) Mechanisms underlying the role of gut-microbiota in exercise-induced changes in cognitive function in middle-age, Reta Lila Weston Trust For Medical Research (2021-2024). Brendon’s on the Editorial Mental Health and Physical Activity. Brendon has received honorarium from a co-edited book on exercise and mental illness, and independent and unrelated advisory work from ASICS, & ParachuteBH and FitXR. The views expressed are those of the author(s) and not necessarily those of mentioned above, the NHS, the NIHR, the Department of Health and Social Care. Felipe Schuch is partly supported by CAPES (Grant 0001). He is on the Editorial board of Mental Health and Physical Activity, Brazilian Journal of Psychiatry and Jornal Brasileiro de Psiquiatria. Felipe has received honorarium from a co-edited book on lifestyle psychiatry, and independent work from FitXR and Pfizer/Upjohn. Henrik Larsson reports receiving grants from Shire Pharmaceuticals; personal fees from and serving as a speaker for Medice, Shire/Takeda Pharmaceuticals and Evolan Pharma AB; and sponsorship for a conference on attention-deficit/hyperactivity disorder from Shire/Takeda Pharmaceuticals and Evolan Pharma AB, all outside the submitted work. Henrik Larsson is editor-in-chief of JCPP Advances. ​​EV has received grants and served as consultant, advisor or CME speaker for the following entities (unrelated to the present work): AB-Biotics, Abbott, Abbvie, Aimentia, Angelini, Biogen, Biohaven, Boehringer Ingelheim, Casen-Recordati, Celon, Compass, Dainippon Sumitomo Pharma, Ethypharm, Ferrer, Gedeon Richter, GH Research, Glaxo Smith-Kline, Idorsia, Janssen, Lundbeck, Novartis, Organon, Otsuka, Rovi, Sage, Sanofi-Aventis, Sunovion, Takeda, and Viatris. HT reports personal fees from Gedeon Richter, Janssen-Cilag, Lundbeck and Otsuka. CUC has been a consultant and/or advisor to or has received honoraria from: AbbVie, Acadia, Alkermes, Allergan, Angelini, Aristo, Biogen, Boehringer-Ingelheim, Cardio Diagnostics, Cerevel, CNX Therapeutics, Compass Pathways, Darnitsa, Denovo, Gedeon Richter, Hikma, Holmusk, IntraCellular Therapies, Janssen/J&J, Karuna, LB Pharma, Lundbeck, MedAvante-ProPhase, MedInCell, Merck, Mindpax, Mitsubishi Tanabe Pharma, Mylan, Neurocrine, Neurelis, Newron, Noven, Novo Nordisk, Otsuka, Pharmabrain, PPD Biotech, Recordati, Relmada, Reviva, Rovi, Seqirus, SK Life Science, Sunovion, Sun Pharma, Supernus, Takeda, Teva, and Viatris. He provided expert testimony for Janssen and Otsuka. He served on a Data Safety Monitoring Board for Compass Pathways, Denovo, Lundbeck, Relmada, Reviva, Rovi, Sage, Supernus, Tolmar and Teva. He has received grant support from Janssen and Takeda. He received royalties from UpToDate and is also a stock option holder of Cardio Diagnostics, Mindpax, LB Pharma, PsiloSterics and Quantic. EDR has served as a speaker for Shire Sweden, AB, a Takeda Pharmaceutical Company outside this work. KL is supported by the Estonian Research Council grant (PSG615).

**ABSTRACT**

Agrowing body of research has demonstrated the potential role for physical activity as an intervention across mental and other medical disorders. However, the association between physical activity and suicidal ideation, attempts, and deaths has not been systematically appraised in clinical samples. We conducted a PRISMA 2020-compliant systematic review searching MEDLINE, EMBASE, and PsycINFO for observational studies investigating the influence of physical activity on suicidal behaviour up to December 6, 2023. Of 116 eligible full-text studies, seven (n=141691) were included. Depression was the most frequently studied c mental condition (43%, k=3), followed by chronic pain as the most common other medical condition (29%, k=2). Two case-control studies examined suicide attempts and found an association between physical activity and a reduced frequency of such attempts. However, in studies examining suicidal ideation (k=3) or suicide deaths (k=2), no consistent associations with physical activity were observed. Overall, our systematic review found that physical activity may be linked to a lower frequency of suicide attempts in non-prospective studies involving individuals with mental disorders.

**Keywords**: Physical activity; mental disorder; medical disorder; suicide

**Introduction**

 Individuals with mental or physical illness are at an increased risk of suicide compared to the general population [[1,2]](https://www.zotero.org/google-docs/?dBCjG4). This is attributable to various factors such as functional limitations, comorbid substance use, and impediments in psychological wellbeing [[3,4]](https://www.zotero.org/google-docs/?ZUujqq). The presence of a mental disorder leads to a significantly higher burden of other medical disorders and vice versa [[5]](https://www.zotero.org/google-docs/?UpdFCN). This overlap has led some to consider abandoning the dichotomy between mental and other medical disorders in favour of a unified terminology and appreciation of bidirectional relationships [[6–8]](https://www.zotero.org/google-docs/?NWy8up). The mechanisms underlying these bidirectional associations are thought to be related to numerous factors, including (but not limited to) autonomic dysregulation, dopamine circuits, unhealthy diets, and physical inactivity [[9–12]](https://www.zotero.org/google-docs/?z1cmKT). Independent of comorbid medical disease, low physical activity levels are associated with increased depression and anxiety, and subsequently suicidal ideation [[13,14]](https://www.zotero.org/google-docs/?SnTm7n). Therefore, it is of utmost importance to address modifiable risk factors such as physical inactivity in order to bolster one's mental and physical health.

Over the last 30 years, a growing body of research has demonstrated a role of physical activity as an effective intervention across mental and other medical disorders [[15,16]](https://www.zotero.org/google-docs/?vaMv6k). Numerous studies have demonstrated the benefits of physical activity on both treating and preventing mental disorders, with similar efficacy compared to pharmacological interventions [[17–21]](https://www.zotero.org/google-docs/?qBiC7I). By improving physical health outcomes, physical activity may mediate improvement in mental health outcomes, similarly reducing suicidal behaviours [[22,23]](https://www.zotero.org/google-docs/?wB1178). As a result, physical activity has been incorporated into international guidelines for the treatment of mental disorders [[24,25]](https://www.zotero.org/google-docs/?oowSJg).

 While the role of lifestyle factors in this is not well established, higher levels of physical activity have been associated with lower rates of suicidal ideation in the general population [[14]](https://www.zotero.org/google-docs/?Ll9uKT). Furthermore, our recent systematic review of randomized controlled trials (RCTs) found that exercise interventions significantly decreased suicide attempts compared to inactive controls in those with mental or physical illness [[23]](https://www.zotero.org/google-docs/?c0Diqk). However, a modest sample size limited power, and no significant difference in suicidal ideation or deaths was observed. Further, the majority of RCTs in the initial systematic review were of low study quality, and often measured suicidal behaviours as adverse events rather than by direct measurement, thus introducing a high risk of bias in measurement and limiting their direct application to clinical practice. Amidst the concerning increase in both the prevalence of mental disorders and the incidence of suicides, we aimed to explore the specific influence of physical activity on suicidal behaviours. This inquiry is particularly crucial considering the known health benefits associated with exercise[[26–29]](https://www.zotero.org/google-docs/?MZXpU4). This facilitates recognition of patient populations who may most benefit from physical activity and will allow for the provision of more targeted therapy. The evidence linking physical activity and suicidal behaviours is currently mixed. Therefore, the purpose of this systematic review is to pool data from observational studies in order to determine the association between physical activity and suicidal ideation, suicide attempts, and suicide deaths across a variety of patients with mental disorders or other medical conditions.

**Methods**

 This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [[30]](https://www.zotero.org/google-docs/?qlwcbq).

***Ethics***

 Research ethics board approval was waived at the University of Ottawa for this type of research. The *a priori* protocol was uploaded to Open Science Framework and can be found at: <https://osf.io/ct7jz/>

***Search Strategy and Inclusion Criteria***

 MEDLINE, EMBASE, and PsycINFO were searched on December 6, 2023 for observational studies investigating the association between physical activity (resistance, aerobic or mind-body) in participants of any age with a mental and/or medical disorders on suicidal outcomes (suicidal ideation, suicide attempts or suicide deaths) with no limits set based on date of publication or language. A librarian was involved to aid in the development of the search strategy. The search terms included exercise, physical activity, and suicide. The full search strategy is available in eTable 1. A manual search was additionally conducted on Google Scholar and in references of eligible studies, and of previous reviews. The research question and inclusion criteria were established *a priori*. Studies were included if they met the following criteria: (a) observational design (prospective cohort, retrospective cohort, or case-control), (b) a portion of participants had a mental and/or medical disorder (or subclinical condition), and (c) report on the effect that any type of exercise or physical activity had on suicidal ideation, suicide attempts or suicide death, regardless of other additional treatment.

***Screening***

 Study screening was conducted on Covidence [[31]](https://www.zotero.org/google-docs/?BYYhCr). Five independent reviewers (AG, SW, JT, IM, SB) screened titles and full texts in duplicate, with discrepancies to be resolved by a third independent reviewer (NF).

***Extraction***

 Four independent reviewers (SW, JT, IM, SB) extracted relevant data from the included studies into a pre-designed Microsoft Excel spreadsheet. All extractions were done in duplicate with discrepancies resolved by consensus. The primary outcomes were suicidal ideation, suicide attempts, and suicide deaths. The maximally adjusted effect sizes (continuous and binary) with corresponding 95% confidence intervals (95% CI) were extracted. In cases where the 95% confidence interval was not reported, the p-value was extracted to estimate the 95% CI. Details of the physical activity or exercise (frequency, intensity, type, and time [FITT]), exercise instructor (expert [physical educators, physiotherapists or exercise physiologists] or not) and compliance with international physical activity guidelines (150 minutes per week of at least moderate or 75 minutes per week of vigorous physical activity) were extracted. Information such as study design (cohort, case-control), first author, year of publication, country, time window, mental/other medical condition, diagnostic criteria, sample size, suicide ideation assessment tool, and demographic data (age, sex, ethnicity) were also extracted.

***Quality Assessment***

 The NIH Study Quality Assessment Tools were used to assess the quality of included studies [[32]](https://www.zotero.org/google-docs/?Gr578G). Four independent reviewers (SW, JT, IM, SB) assessed each criterion of the checklist in duplicate with discrepancies resolved by consensus. For cohort (prospective or retrospective) studies, the following scores were used: 0-5 (poor), 6-10 (fair), 11-14 (good). For case-control studies, the following scores were used: 0-4 (poor), 5-8 (fair), 9-12 (good).

**Results**

***Study and Participant Characteristics***

The search identified 1505 studies, and after removing 437 duplicates, 1068 studies were screened. One hundred sixteen full-texts were reviewed of which 109 were excluded; reasons for exclusion are illustrated in **Figure 1, with the list of excluded studies and reasons for exclusion in the supplementary materials. *Seven*** studies met eligibility for extraction, all of which were published between 2004 and 2022.

Study characteristics and exercise details are summarized in **Table 1. Five** studies (71%) were prospective cohorts, while two studies (29%) were case-control studies. They most commonly originated from the United States (57%, k = 4). Depression was the most commonly included mental disorder (43%, k = 3), and chronic pain was the most commonly included other medical condition (29%, k = 2). Aerobic exercise was the most commonly assessed type of exercise (43%, k = 3); no studies commented on muscle strengthening exercises. Finally, the most common control group was physically inactive or sedentary individuals (43%, k = 3).

Participant characteristics are summarized in **Table 1.** Altogether, 141691 participants were included in the studies captured by this systematic review. Females represented 4.5% (n = 6384) of this sample, and the mean age was 32.0 years. Among the 3 studies that reported ethnicity, individuals were most commonly White (n = 41 370; 61.5%).

***Suicidal Ideation***

 Three studies (n = 67508) analyzed suicidal ideation [[33–35]](https://www.zotero.org/google-docs/?SYUjrH). In Meerwijk and colleagues’ (2022) prospective cohort study composed of 66 257 active duty soldiers with chronic pain, those who regularly exercised (n = 37 310) generally showed non-significant differences in suicidal ideation compared to controls who did not exercise [[33]](https://www.zotero.org/google-docs/?tjehaJ). When stratified by the number of exercise therapy visits, participants who participated in 4-5 (HR = 0.85, 95%CI 0.74-0.97, *p* < 0.05), 8-9 (HR = 0.83, 95%CI 0.70-0.97, *p* < 0.05), and >9 total visits (HR = 0.85, 95%CI 0.76-0.95, *p* < 0.01) were significantly associated with reduced suicidal ideation. In Kang and colleagues’ (2013) prospective cohort consisting of 1204 patients with chronic mental illnesses (e.g., depression, anxiety), physical inactivity was not associated with a significant difference in incidence of suicidal ideation (OR = 1.09, 95%CI 0.61-1.94) [[34]](https://www.zotero.org/google-docs/?VOw0Bz). In Perez and colleagues’ (2022) prospective cohort consisting of 47 participants with major depressive disorder, physical activity level (light standing, light ambulatory and moderate-to-vigorous physical activity) over 7 days as measured by accelerometer/inclinometer was not significantly associated with suicidal ideation [[35]](https://www.zotero.org/google-docs/?8WA5to). However, when restricted to the cohort of participants in a major depressive episode (n = 38), light ambulatory physical activity reduced the risk of low (OR = 0.910, 95%CI 0.84-0.98, p = 0.018) and moderate/high (OR = 0.92, 95% CI 0.85-1.00, p = 0.036) suicidal ideation.

***Suicide Attempts***

 Two studies (n = 947) analyzed suicide attempts [[36,37]](https://www.zotero.org/google-docs/?fUuHyx). In Perera and colleagues’ (2018) case-control study composed of 281 patients admitted to a psychiatric inpatient unit, cases who had a history of suicide attempts were significantly less likely to engage in mild (OR = 0.12, 95%CI 0.04-0.39, *p* < 0.001) or moderate/intense exercise (OR = 0.15, 95%CI 0.05-0.48, *p* = 0.001) compared to those without [[36]](https://www.zotero.org/google-docs/?z6rxs2). Simon and colleagues (2004) conducted a case-control study consisting of 153 individuals with depression, hopelessness, alcoholism or any serious medical condition, with near lethal suicide attempts, and 513 controls randomly selected from the same catchment area. They found that having had no physical activity was associated with a greater odds of suicide attempts (OR = 6.06, 95%CI 2.83-12.95, *p*-value NR) [[37]](https://www.zotero.org/google-docs/?2j0VO1).

***Suicide Deaths***

 Two studies (n = 73 236) analyzed suicide mortality [[38,39]](https://www.zotero.org/google-docs/?gpOHNy). In Mukamal and colleagues’ (2007) prospective cohort study composed of 46 755 individuals with obesity, higher intensity of exercise (up to 41.99 MET-hr per week) was not significantly associated with reduced risk of suicide deaths compared to inactive individuals (defined as <6.33 MET-hr per week) [[39]](https://www.zotero.org/google-docs/?inbtZa). In Kikuchi and colleagues’ (2009) prospective cohort study consisting of 26 481 individuals with chronic pain, self-reported walking duration was not significantly associated with suicide deaths, irrespective of pain intensity [[38]](https://www.zotero.org/google-docs/?FOaVLe).

***Quality Assessment***

The NIH quality assessments are available in **Table 3** and **Table 4.** Overall, 86% (k = 6) of the studies were rated as good quality, 14% (k = 1) of the studies were rated as fair quality. The most common limitation was lack of blinding to exposure or outcomes (k = 4, 57%).

**Discussion:**

 In this review, we sought to examine the association between physical activity and suicide-related behaviours and ideation in people with long-term health conditions. Seven observational studies were included, of fair to good quality. Due to significant methodological heterogeneity, quantitative synthesis through meta-analyses of outcomes such as suicidal ideation, suicide attempts and suicide deaths was not possible. The two studies which examined suicide attempts both found physical activity to be associated with less frequent attempts. Both of these studies utilized a case-control design and were not prospective. In the studies examining suicidal ideation and/or suicide deaths, no consistent associations with physical activity were observed.

 For the three studies which examined suicidal ideation, associations with physical activity were inconsistent [[33–35]](https://www.zotero.org/google-docs/?3tQRJt). In a 2-year prospective cohort of elderly Korean adults with comorbid mental and physical illness, Kang and colleagues (2013) found no association between physical inactivity and suicidal ideation as measured by the Geriatric Mental State diagnostic schedule (GMS B3) [[34]](https://www.zotero.org/google-docs/?aSHFAf). The presence of suicidal ideation was evaluated at baseline and subsequently at a 2-year follow-up. No significant changes in suicidal ideation were observed for either the subgroup with suicidal ideation at baseline or the other without suicidal ideation. Along with this, a prospective cohort of active duty army soldiers with chronic pain who subsequently enrolled in the Veterans Health Administration (VHA) by Meerwijk and colleagues (2022) found inconsistent associations between exercise therapy exposure and suicidal ideation, as determined by ICD-9 and ICD-10 diagnoses recorded in the VHA healthcare records [[33]](https://www.zotero.org/google-docs/?v81iTN). Subgroup analyses were conducted based on number of exercise therapy visits and generally found that greater attendance to exercise therapy (greater frequency of exercise) was associated with statistically significant decreases in suicidal ideation, whereas <3 visits did not show a significant association. Further, a prospective cohort by Perez and colleagues (2022) found that physical activity levels as measured by accelerometer/inclinometer were not associated with suicidal ideation in those with major depressive disorder [[35]](https://www.zotero.org/google-docs/?3P3eum). However, when analyzing solely the subgroup experiencing a major depressive episode, there were very modest reductions in suicidal ideation only for light ambulatory, but not for moderate-to-vigorous physical activity based on intensity. Our previous meta-analysis of randomized controlled trials (RCTs) similarly did not demonstrate a significant change in suicidal ideation (as quantified by standardized scales or as a binary outcome) following exercise intervention [[23]](https://www.zotero.org/google-docs/?yJwf0m). However, a meta-analysis of cross-sectional studies by Vancamport and colleagues (2018) concluded that increased levels of physical activity were associated with lower suicidal ideation in the general population [[14]](https://www.zotero.org/google-docs/?ZDQaRo). Given the cross-sectional nature of these meta-analyzed studies, one must acknowledge their vulnerability to confounding variables such as the adoption of other healthy lifestyle habits alongside physical activity which have been shown to independently reduce suicidal ideation [[40,41]](https://www.zotero.org/google-docs/?3iDrah). Further, physical activity is often conducted within a group setting offering social support to those who regularly partake [[42]](https://www.zotero.org/google-docs/?cispww). This social support has been shown to independently reduce suicidal ideation, irrespective of the presence of physical activity [[43]](https://www.zotero.org/google-docs/?Jvw4bK). Therefore, the relationship between physical activity and suicidal ideation requires further research which adequately controls for confounding variables to accurately assess this association.

 Physical activity was associated with a lower risk of suicide attempts in both included studies [[36,37]](https://www.zotero.org/google-docs/?yvf2IJ). Specifically, in a case-control study of psychiatric inpatients compared to community controls admitted to hospital, Perera and colleagues (2018) concluded that those who attempted suicide had a decreased likelihood of being physically active than their controls without suicide attempts. Physical activity was measured by the International Physical Activity Questionnaire and the decreased odds were observed for mild, moderate and strenuous physical activity. [[36]](https://www.zotero.org/google-docs/?v7TMtr). Similarly, in a case-control study of individuals with nearly lethal suicide attempts compared to community controls recruited by telephone, Simon and colleagues (2004) found that those that attempted suicide were less likely than controls to report involvement in physical activity in the past month [[37]](https://www.zotero.org/google-docs/?AUjnBJ). This association was maintained by subanalysis based on intensity, frequency, and duration of physical activity. These findings are in keeping with our previous meta-analysis of RCTs, where individuals with mental or physical illness randomized to exercise had significantly fewer suicide attempts compared to inactive controls [[23]](https://www.zotero.org/google-docs/?pC93qJ). The inconsistent association of physical activity with less frequent suicide attempts, but not with suicidal ideation, can be rationalized through the ideation-to-action framework which states that suicidal ideation and suicide attempts are two distinct processes with specific influential factors [[44]](https://www.zotero.org/google-docs/?rOPt3q). Therefore, since most suicide attempts are characterized by emotional impulsivity which physical activity has been demonstrated to reduce, we posit that higher levels of physical activity lead to a lower number of suicide attempts [[45–47]](https://www.zotero.org/google-docs/?XEP92T). With this in mind, physical activity may prove to be an effective measure of suicide attempt reduction in those with chronic conditions which place them at elevate risk such as borderline personality disorder (BPD), however further research is required in this area, particularly distinguishing between exercise type, volume and intensity [[48]](https://www.zotero.org/google-docs/?6x3J9T).

 There was no association found between physical activity and risk of death by suicide in both studies included within this review [[38,39]](https://www.zotero.org/google-docs/?cHxR51). In a prospective cohort study of men free of cancer, Mukamal and colleagues (2007) concluded that physical activity (irrespective of intensity) was not associated with reduced risk of suicide death compared to inactive controls, but instead was inversely related to body mass index (BMI) [[39]](https://www.zotero.org/google-docs/?sna3SC). Similarly, in a prospective cohort study of Japanese men with chronic pain, Kikuchi and colleagues (2009) found no association between self-reported walking and suicide deaths, however suicide was significantly higher in subjects with more pain [[38]](https://www.zotero.org/google-docs/?zRZ4BE). This is in keeping with our previous meta-analysis of RCTs where no difference in suicide deaths were observed between those exercising compared to inactive controls [[23]](https://www.zotero.org/google-docs/?9hdTps). It is clear that regular physical activity has numerous multi-system benefits such as reduced cardiovascular mortality, reduction in chronic pain, increased physical function, and improved quality of sleep, however may not directly reduce suicide-related mortality [[49–51]](https://www.zotero.org/google-docs/?qfRcCh). It is important to consider however that both studies which analyzed suicide deaths in this systematic review included exclusively male participants [[38,39]](https://www.zotero.org/google-docs/?1e3FcC). Research has demonstrated that although males make less suicide attempts than females, their attempts are of higher lethality [[52]](https://www.zotero.org/google-docs/?SEOwex). This may impact our results if the association is moderated by sex, gender, or attempt severity.

Strengths

 There were numerous strengths of this study. Firstly, reporting bias was minimized through the production of an *a priori* protocol. Our search was conducted across various databases and included grey literature to minimize publication bias. All screening and extraction were conducted in duplicate which ensured accuracy and integrity of our data. Although solely including observational studies, we excluded those with cross-sectional designs due to their inability to discern temporal relations and significant vulnerabilities to the effects of confounding. Lastly, as literature focusing on the relationship between physical activity and mental health has been of increasing interest over recent years, this systematic review benefits from having the most current information available.

Limitations

 The main limitation of this study is the small number of studies included and their heterogeneity, which did not allow for conducting a meta-analysis. Foremost, meta-analyses of outcomes variables such as suicidal ideation, suicide attempts and suicide deaths was not possible due to significant methodological heterogeneity among included studies. Moreover, we did not include RCTs in the current review but was conducted separately [[23]](https://www.zotero.org/google-docs/?CAKgGD), which challenges inferences about causality between exposure and outcome given potential for confounding in observational studies, including medication[[53]](https://www.zotero.org/google-docs/?ojwuxS). Also, in the studies we extracted data from, we found that details regarding physical activity or exercise were often not adequately reported. For instance, no study commented on muscle strengthening exercises nor provided further details on exercise intensity or volume. We recommend that future research on this topic more clearly and consistently detail physical activity, specifically following the FITT parameters to allow for an operational definition of physical activity that could then be compared between studies. Further, to achieve more complete and robust evidence, higher quality and additional observational studies investigating this topic are essential. These observational studies should particularly focus on blinding to exposure and outcome, which was the most common limitation found on our quality assessment. As the majority of studies in this review focused on depression or chronic pain, future studies should aim to explore the influence of physical activity in a variety of mental or other medical conditions to get a more comprehensive overview. Thus, we are aware of the potential bias in the review process, as we may have overlooked certain studies which did not explicitly fall in but may have reported relevant findings. Thus there is a possibility that at initial search, some studies might have been omitted and thus could not be extracted from the studies identified within the initial search. The generalizability of our findings is also of concern since there was an extreme underrepresentation of female participants (4.5%) and no physical disorders beyond chronic pain. While some studies utilized prospective cohort designs, the case-control studies involved retrospective estimations of physical activity, which may be prone to bias. We cannot rule out differential misclassification based on case vs. control status.

Conclusions

Overall, our systematic review found that aerobic physical activity was associated with decreased suicide attempts in those with mental disorders. However, we found no association between physical activity and suicidal ideation among patients with mental disorders or suicide deaths among patients with physical disorders. Results are consistent with evidence from trials. Due to the observational character of the included study, we cannot conclude anything about the direction of the associations, and we cannot exclude that a common underlying variable can explain the findings. The association with suicide attempts but not suicidal ideation might be due to physical activity-induced reductions in impulsivity preceding suicide attempts. Future research across a variety of mental disorders and other medical conditions which adequately control for confounding variables known to influence the association and between physical activity and suicidal behaviours are required to better understand this relationship, quantify the physiological mechanisms, and identify the minimal clinically-important difference for physical activity and suicidal behaviours.

Acknowledgements

 None

**eTable 1: Search strategy**

|  |  |  |
| --- | --- | --- |
| Ovid MEDLINE(R) ALL <1946 to December 6, 2023>  1 exp Exercise/ or exp Physical Fitness/ or exp Sports/ 3418922 exp Mind-Body Therapies/ or yoga/ 463493 (exercis\* or aerobic\* or resistance train\*).tw,kf. 4280554 exp Exercise Therapy/ 610125 (physical activity or mind body or yoga).tw,kf. 1477596 (Sport\* or Athletic Performance or Baseball or Basketball or Bicycling or Boxing or Football or Golf or Gymnastic\* or Hockey or Martial Arts or Mountaineering or Rugby or Running or Skating or skiing or Soccer or Volleyball or Walking or Weight Lifting or Wrestling).tw,kf. 2734447 or/1-6 8841138 Suicide/ or Suicide, Completed/ or Suicide, Attempted/ 614329 exp Self-Injurious Behavior/ 8093010 (suicid\* or self-harm or self injur\* or self mutilat\*).tw,kf. 9990711 8 or 9 or 10 12035812 7 and 11 194413 exp Cohort Studies/ 240651114 (cohort\* or retrospective\* or prospective\*).tw. 215520215 case-control studies/ 32407116 ((case control\* or case based) adj2 stud\*).tw. 13011917 Registries/ 10621618 follow up.tw. 114193319 Epidemiologic Studies/ 918720 Epidemiol\*.tw,kf. 49093421 or/13-20 429057022 12 and 21 39723 exp animals/ not humans/ 505668624 22 not 23 395   | Embase Classic+Embase <1947 to 2023 December 6> 1 exp exercise/ or exp sport/ 5871432 exp kinesiotherapy/ 984383 (physical activity or mind body or yoga).tw. 1936254 (exercis\* or aerobic\* or resistance train\*).tw. 5666755 (Sport\* or Athletic Performance or Baseball or Basketball or Bicycling or Boxing or Football or Golf or Gymnastic\* or Hockey or Martial Arts or Mountaineering or Rugby or Running or Skating or skiing or Soccer or Volleyball or Walking or Weight Lifting or Wrestling).tw. 3587526 or/1-5 11673937 exp suicidal behavior/ 1248168 automutilation/ 231089 (suicid\* or self-harm or self injur\*).tw. 12654910 or/7-9 16925911 6 and 10 336512 cohort analysis/ 90923513 retrospective study/ 133021614 prospective study/ 80546415 (cohort\* or retrospective\* or prospective\*).tw. 347970216 exp case control study/ 21244317 ((case control\* or case based) adj2 stud\*).tw. 16951118 \*register/ 2630519 follow up.tw. 184062520 \*follow up/ 5713621 epidemiol\*.tw. 56896722 epidemiology/ 25688723 or/12-22 569350324 11 and 23 675 | APA PsycInfo <1806 to December Week 1 2023>  1 exp exercise/ or physical activity/ or kinesiology/ or physical fitness/ 520932 mind body therapy/ 3373 yoga/ 22794 (exercis\* or aerobic\* or resistance train\*).tw. 801405 (physical activity or mind body or yoga).tw. 497846 exp sports/ 391587 (Sport\* or Athletic Performance or Baseball or Basketball or Bicycling or Boxing or Football or Golf or Gymnastic\* or Hockey or Martial Arts or Mountaineering or Rugby or Running or Skating or skiing or Soccer or Volleyball or Walking or Weight Lifting or Wrestling).tw. 855888 1 or 2 or 3 or 4 or 5 or 6 or 7 1981459 exp suicide/ or exp self-injurious behavior/ or suicidal ideation/ 4957210 (suicid\* or self-harm or self injur\* or self mutilat\*).tw. 8267711 9 or 10 8350512 8 and 11 158313 cohort analysis/ 164614 longitudinal studies/ or prospective studies/ or followup studies/ or retrospective studies/ 3032115 Quasi Experimental Methods/ 45516 (observational adj3 (study or studies or design or analysis or analyses)).tw. 1813417 cohort\*.tw. 9371118 prospective\*.tw. 7835419 follow up.tw. 13466220 ((longitudinal or longterm or (long adj term)) adj7 (study or studies or design or analysis or analyses or data)).tw. 12458821 retrospective\*.tw. 5070922 ((case adj control) or (case adj comparison) or (case adj controlled)).tw. 1298823 (case-referent adj3 (study or studies or design or analysis or analyses)).tw. 2024 epidemiology/ 5430025 epidemiol\*.tw. 5809726 (population adj3 (study or studies or analysis or analyses)).tw. 3274327 (descriptive adj3 (study or studies or design or analysis or analyses)).tw. 3176928 or/13-27 52981829 12 and 28 293 |

**References**

[1. Harris EC, Barraclough B. Suicide as an outcome for mental disorders. A meta-analysis. Br J Psychiatry J Ment Sci. 1997;170:205–28.](https://www.zotero.org/google-docs/?ZiEjAd)

[2. Jia C-X, Wang L-L, Xu A-Q, Dai A-Y, Qin P. Physical illness and suicide risk in rural residents of contemporary China: A psychological autopsy case-control study. Crisis J Crisis Interv Suicide Prev. 2014;35:330–7.](https://www.zotero.org/google-docs/?ZiEjAd)

[3. Kaplan MS, McFarland BH, Huguet N, Newsom JT. Physical Illness, Functional Limitations, and Suicide Risk: A Population-Based Study. Am J Orthopsychiatry. 2007;77:56–60.](https://www.zotero.org/google-docs/?ZiEjAd)

[4. Hawton K, Casañas i Comabella C, Haw C, Saunders K. Risk factors for suicide in individuals with depression: A systematic review. J Affect Disord. 2013;147:17–28.](https://www.zotero.org/google-docs/?ZiEjAd)

[5. Evans DL, Charney DS, Lewis L, Golden RN, Gorman JM, Krishnan KRR, et al. Mood Disorders in the Medically Ill: Scientific Review and Recommendations. Biol Psychiatry. 2005;58:175–89.](https://www.zotero.org/google-docs/?ZiEjAd)

[6. Baker M, Menken M. Time to abandon the term mental illness. BMJ. 2001;322:937.](https://www.zotero.org/google-docs/?ZiEjAd)

[7. Holt RIG, Phillips DIW, Jameson KA, Cooper C, Dennison EM, Peveler RC. The relationship between depression, anxiety and cardiovascular disease: Findings from the Hertfordshire Cohort Study. J Affect Disord. 2013;150:84–90.](https://www.zotero.org/google-docs/?ZiEjAd)

[8. Dragioti E, Radua J, Solmi M, Gosling CJ, Oliver D, Lascialfari F, et al. Impact of mental disorders on clinical outcomes of physical diseases: an umbrella review assessing population attributable fraction and generalized impact fraction. World Psychiatry Off J World Psychiatr Assoc WPA. 2023;22:86–104.](https://www.zotero.org/google-docs/?ZiEjAd)

[9. Bonnet F, Irving K, Terra J-L, Nony P, Berthezène F, Moulin P. Anxiety and depression are associated with unhealthy lifestyle in patients at risk of cardiovascular disease. Atherosclerosis. 2005;178:339–44.](https://www.zotero.org/google-docs/?ZiEjAd)

[10. Joynt KE, Whellan DJ, O’Connor CM. Depression and cardiovascular disease: mechanisms of interaction. Biol Psychiatry. 2003;54:248–61.](https://www.zotero.org/google-docs/?ZiEjAd)

[11. Zhang J, He Z, Qu Y, Li L, Wang L, Yuan W, et al. Different baseline physical activity predicts susceptibility and resilience to chronic social defeat stress in mice: Involvement of dopamine neurons. Eur Neuropsychopharmacol. 2021;45:15–28.](https://www.zotero.org/google-docs/?ZiEjAd)

[12. Koch ED, Freitag CM, Mayer JS, Medda J, Reif A, Grimm O, et al. The dynamical association between physical activity and affect in the daily life of individuals with ADHD. Eur Neuropsychopharmacol. 2022;57:69–74.](https://www.zotero.org/google-docs/?ZiEjAd)

[13. Ma R, Romano E, Vancampfort D, Firth J, Stubbs B, Koyanagi A. Association between physical activity and comorbid anxiety/depression in 46 low- and middle-income countries. J Affect Disord [Internet]. 2022 [cited 2022 Oct 10]; Available from: https://www.sciencedirect.com/science/article/pii/S0165032722011843](https://www.zotero.org/google-docs/?ZiEjAd)

[14. Vancampfort D, Hallgren M, Firth J, Rosenbaum S, Schuch FB, Mugisha J, et al. Physical activity and suicidal ideation: A systematic review and meta-analysis. J Affect Disord. 2018;225:438–48.](https://www.zotero.org/google-docs/?ZiEjAd)

[15. Sabe M, Chen C, Sentissi O, Deenik J, Vancampfort D, Firth J, et al. Thirty years of research on physical activity, mental health, and wellbeing: A scientometric analysis of hotspots and trends. Front Public Health [Internet]. 2022 [cited 2022 Oct 10];10. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2022.943435](https://www.zotero.org/google-docs/?ZiEjAd)

[16. Sallis R. Exercise is medicine: a call to action for physicians to assess and prescribe exercise. Phys Sportsmed. 2015;43:22–6.](https://www.zotero.org/google-docs/?ZiEjAd)

[17. Carek PJ, Laibstain SE, Carek SM. Exercise for the Treatment of Depression and Anxiety. Int J Psychiatry Med. 2011;41:15–28.](https://www.zotero.org/google-docs/?ZiEjAd)

[18. Dunn AL, Trivedi MH, Kampert JB, Clark CG, Chambliss HO. Exercise treatment for depression: Efficacy and dose response. Am J Prev Med. 2005;28:1–8.](https://www.zotero.org/google-docs/?ZiEjAd)

[19. Kim S-Y, Park J-H, Lee MY, Oh K-S, Shin D-W, Shin Y-C. Physical activity and the prevention of depression: A cohort study. Gen Hosp Psychiatry. 2019;60:90–7.](https://www.zotero.org/google-docs/?ZiEjAd)

[20. Mota-Pereira J, Silverio J, Carvalho S, Ribeiro JC, Fonte D, Ramos J. Moderate exercise improves depression parameters in treatment-resistant patients with major depressive disorder. J Psychiatr Res. 2011;45:1005–11.](https://www.zotero.org/google-docs/?ZiEjAd)

[21. Recchia F, Leung CK, Chin EC, Fong DY, Montero D, Cheng CP, et al. Comparative effectiveness of exercise, antidepressants and their combination in treating non-severe depression: a systematic review and network meta-analysis of randomised controlled trials. Br J Sports Med [Internet]. 2022 [cited 2022 Oct 10]; Available from: https://bjsm.bmj.com/content/early/2022/09/23/bjsports-2022-105964](https://www.zotero.org/google-docs/?ZiEjAd)

[22. Croatto G, Vancampfort D, Miola A, Olivola M, Fiedorowicz JG, Firth J, et al. The impact of pharmacological and non-pharmacological interventions on physical health outcomes in people with mood disorders across the lifespan: An umbrella review of the evidence from randomised controlled trials. Mol Psychiatry. 2022;1–22.](https://www.zotero.org/google-docs/?ZiEjAd)

[23. Fabiano N, Gupta A, Fiedorowicz JG, Firth J, Stubbs B, Vancampfort D, et al. The effect of exercise on suicidal ideation and behaviors: A systematic review and meta-analysis of randomized controlled trials. J Affect Disord. 2023;330:355–66.](https://www.zotero.org/google-docs/?ZiEjAd)

[24. Marx W, Manger SH, Blencowe M, Murray G, Ho FY-Y, Lawn S, et al. Clinical guidelines for the use of lifestyle-based mental health care in major depressive disorder: World Federation of Societies for Biological Psychiatry (WFSBP) and Australasian Society of Lifestyle Medicine (ASLM) taskforce. World J Biol Psychiatry. 2022;0:1–54.](https://www.zotero.org/google-docs/?ZiEjAd)

[25. Stubbs B, Vancampfort D, Hallgren M, Firth J, Veronese N, Solmi M, et al. EPA guidance on physical activity as a treatment for severe mental illness: a meta-review of the evidence and Position Statement from the European Psychiatric Association (EPA), supported by the International Organization of Physical Therapists in Mental Health (IOPTMH). Eur Psychiatry J Assoc Eur Psychiatr. 2018;54:124–44.](https://www.zotero.org/google-docs/?ZiEjAd)

[26. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. The Lancet. 2006;367:1747–57.](https://www.zotero.org/google-docs/?ZiEjAd)

[27. Mathers CD, Loncar D. Projections of Global Mortality and Burden of Disease from 2002 to 2030. PLOS Med. 2006;3:e442.](https://www.zotero.org/google-docs/?ZiEjAd)

[28. Naghavi M. Global, regional, and national burden of suicide mortality 1990 to 2016: systematic analysis for the Global Burden of Disease Study 2016. BMJ. 2019;364:l94.](https://www.zotero.org/google-docs/?ZiEjAd)

[29. Sagar R, Dandona R, Gururaj G, Dhaliwal RS, Singh A, Ferrari A, et al. The burden of mental disorders across the states of India: the Global Burden of Disease Study 1990–2017. Lancet Psychiatry. 2020;7:148–61.](https://www.zotero.org/google-docs/?ZiEjAd)

[30. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.](https://www.zotero.org/google-docs/?ZiEjAd)

[31. Veritas Health Information. Covidence systematic review software [Internet]. Melbourne, Australia; Available from: www.covidence.org](https://www.zotero.org/google-docs/?ZiEjAd)

[32. Study Quality Assessment Tools | NHLBI, NIH [Internet]. [cited 2022 Oct 10]. Available from: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools](https://www.zotero.org/google-docs/?ZiEjAd)

[33. Meerwijk EL, Sayko Adams R, Larson MJ, Highland KB, Harris AHS. Dose of Exercise Therapy Among Active Duty Soldiers With Chronic Pain Is Associated With Lower Risk of Long-Term Adverse Outcomes After Linking to the Veterans Health Administration. Mil Med. 2022;usac074.](https://www.zotero.org/google-docs/?ZiEjAd)

[34. Kang H-J, Stewart R, Jeong B-O, Kim S-Y, Bae K-Y, Kim S-W, et al. Suicidal ideation in elderly Korean population: a two-year longitudinal study. Int Psychogeriatr. 2014;26:59–67.](https://www.zotero.org/google-docs/?ZiEjAd)

[35. Perez ML, Ellingson LD, Meyer JD. Physical Activity, Sedentary Behavior, and Suicidal Ideation in Major Depressive Disorder. Arch Suicide Res Off J Int Acad Suicide Res. 2022;1–18.](https://www.zotero.org/google-docs/?ZiEjAd)

[36. Perera S, Eisen RB, Bhatt M, Dennis BB, Bawor M, El-Sheikh W, et al. Exploring metabolic factors and health behaviors in relation to suicide attempts: A case-control study. J Affect Disord. 2018;229:386–95.](https://www.zotero.org/google-docs/?ZiEjAd)

[37. Simon TR, Powell KE, Swann AC. Involvement in physical activity and risk for nearly lethal suicide attempts. Am J Prev Med. 2004;27:310–5.](https://www.zotero.org/google-docs/?ZiEjAd)

[38. Kikuchi N, Ohmori-Matsuda K, Shimazu T, Sone T, Kakizaki M, Nakaya N, et al. Pain and Risk of Completed Suicide in Japanese Men: A Population-Based Cohort Study in Japan (Ohsaki Cohort Study). J Pain Symptom Manage. 2009;37:316–24.](https://www.zotero.org/google-docs/?ZiEjAd)

[39. Mukamal KJ. Body Mass Index and Risk of Suicide Among Men. Arch Intern Med. 2007;167:468.](https://www.zotero.org/google-docs/?ZiEjAd)

[40. Tucker RP, O’Keefe VM, Cole AB, Rhoades-Kerswill S, Hollingsworth DW, Helle AC, et al. Mindfulness tempers the impact of personality on suicidal ideation. Personal Individ Differ. 2014;68:229–33.](https://www.zotero.org/google-docs/?ZiEjAd)

[41. Goodwin RD, Marusic A. Association Between Short Sleep and Suicidal Ideation and Suicide Attempt Among Adults in the General Population. Sleep. 2008;31:1097–101.](https://www.zotero.org/google-docs/?ZiEjAd)

[42. Wankel LM, Berger BG. The Psychological and Social Benefits of Sport and Physical Activity. J Leis Res. 1990;22:167–82.](https://www.zotero.org/google-docs/?ZiEjAd)

[43. Miller AB, Esposito-Smythers C, Leichtweis RN. Role of Social Support in Adolescent Suicidal Ideation and Suicide Attempts. J Adolesc Health. 2015;56:286–92.](https://www.zotero.org/google-docs/?ZiEjAd)

[44. Klonsky ED, May AM. The Three-Step Theory (3ST): A New Theory of Suicide Rooted in the “Ideation-to-Action” Framework. Int J Cogn Ther. 2015;8:114–29.](https://www.zotero.org/google-docs/?ZiEjAd)

[45. Lopez-Castroman J, Nogue E, Guillaume S, Picot MC, Courtet P. Clustering Suicide Attempters: Impulsive-Ambivalent, Well-Planned, or Frequent. J Clin Psychiatry. 2016;77:3097.](https://www.zotero.org/google-docs/?ZiEjAd)

[46. Javelle F, Vogel A, Laborde S, Oberste M, Watson M, Zimmer P. Physical exercise is tied to emotion-related impulsivity: insights from correlational analyses in healthy humans. Eur J Sport Sci. 2022;0:1–8.](https://www.zotero.org/google-docs/?ZiEjAd)

[47. Cerrillo-Urbina AJ, García-Hermoso A, Sánchez-López M, Pardo-Guijarro MJ, Santos Gómez JL, Martínez-Vizcaíno V. The effects of physical exercise in children with attention deficit hyperactivity disorder: a systematic review and meta-analysis of randomized control trials. Child Care Health Dev. 2015;41:779–88.](https://www.zotero.org/google-docs/?ZiEjAd)

[48. Brodsky BS, Groves SA, Oquendo MA, Mann JJ, Stanley B. Interpersonal Precipitants and Suicide Attempts in Borderline Personality Disorder. Suicide Life Threat Behav. 2006;36:313–22.](https://www.zotero.org/google-docs/?ZiEjAd)

[49. Strasser B. Physical activity in obesity and metabolic syndrome. Ann N Y Acad Sci. 2013;1281:141–59.](https://www.zotero.org/google-docs/?ZiEjAd)

[50. Gordon R, Bloxham S. A Systematic Review of the Effects of Exercise and Physical Activity on Non-Specific Chronic Low Back Pain. Healthcare. 2016;4:22.](https://www.zotero.org/google-docs/?ZiEjAd)

[51. Sullivan Bisson AN, Robinson SA, Lachman ME. Walk to a better night of sleep: testing the relationship between physical activity and sleep. Sleep Health. 2019;5:487–94.](https://www.zotero.org/google-docs/?ZiEjAd)

[52. Prediction of Lethality in Suicide Attempts: Gender Matters - Carol C. Choo, Keith M. Harris, Roger C. Ho, 2019 [Internet]. [cited 2023 Mar 5]. Available from: https://journals.sagepub.com/doi/10.1177/0030222817725182](https://www.zotero.org/google-docs/?ZiEjAd)

[53. Ilzarbe L, Vieta E. The elephant in the room: Medication as confounder. Eur Neuropsychopharmacol. 2023;71:6–8.](https://www.zotero.org/google-docs/?ZiEjAd)

**Image & Table Legend**

Figure 1: PRISMA Diagram

Table 1: Patient and Study Characteristics

Table 2: Summary of Study Results

Table 3: NIH Quality Assessment for Cohort Studies

Table 4: NIH Quality Assessment for Case-Control Studies

**Figure 1: PRISMA Diagram**

****

**Table 1: Patient and Study Characteristics**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Study Type** | **Country** | **Sample Size** | **Mean Age** | **% Females** | **Condition** | **Exercise Details** | **Number of Patients in Exercise Group** | **Control Details** | **Number of Patients in Control Group** |
| Meerwijk 2022 | PC | USA | 66257 | 27.8 | 7.8 | Chronic pain | Exercise therapy (covers a wide range of therapeutic procedures that include, among others, treadmill, isokinetic exercise, lumbar stabilization, stretching, strengthening, neuromuscular re-education, gait training, and aquatic exercise) | 37 310 | No exercise therapy | 28 947 |
| Mukamal 2007 | PC | USA | 46755 | 54.4 | 0.0 | High BMI (>30) | Active (≥6.33 MET-hr/week) | NR | Inactive (<6.33 MET-hr/week) | NR |
| Perera 2018 | CC | Canada | 281 | 44.9 | 50.5 | Post-Suicide-Attempt | Mild to strenuous physical activity during leisure time | 208 | Sedentary during leisure time | 62 |
| Simon 2004 | CC | USA | 666 | Mean NR (range 13-34) | 54.4 | Depression, Hopelessness, Alcoholism or any Medical Condition | Running, calisthenics, golf, gardening, or walking for exercise >=1x/week | 508 | No running, calisthenics, golf, gardening, or walking for exercise (0x/week) | 156 |
| Kang 2013 | PC | South Korea | 1204 | 72.2 | 58.0 | Depression, anxiety, insomnia, or any chronic medical illness | Physically Active | 852 | Physically Inactive | 352 |
| Kikuchi 2009 | PC | Japan | 26481 | 59.6 | 0.0 | Chronic pain | Self-reported walking duration ≥1hr/day | 10 298 | Self-reported walking duration <1hr/day | 10 785 |
| Perez 2022 | PC | USA | 47 | 30.0 | 72.3 | Major depressive disorder | Moderate-to-vigorous, light standing/ambulatory physical activity based on accelerometer/inclinometer for 7 days | NR | Sedentary behaviours based on accelerometer/inclinometer for 7 days | NR |

Abbreviations: case control (CC), prospective cohort (PC), not reported (NR)

**Table 2: Summary of Study Results**

|  |  |  |  |
| --- | --- | --- | --- |
| **Study** | **Suicide Ideation** | **Suicide Attempts** | **Suicide Deaths** |
| Meerwijk 2022 | * No Exercise Therapy: Reference
* 1 visit: HR = 1.02 (95%CI 0.91-1.15)
* 2–3 visits: HR = 0.9 (95%CI 0.79-1.01)
* 4–5 visits: HR = 0.85 (95%CI 0.74-0.97)
* 6–7 visits: HR = 0.98 (95%CI 0.85-1.13)
* 8–9 visits: HR = 0.83 (95%CI 0.70-0.97)
* >9 visits: HR = 0.85 (95%CI 0.76-0.95)
 | NR | NR |
| Mukamal 2007 | NR | * NR
 | * <6.33 MET-hr/week: Reference
* 6.33-14.49 MET-hr/week: HR = 0.82 (95%CI 0.46-1.45)
* 14.50-25.08 MET-hr/week: HR = 0.86 (95%CI 0.48-1.52)
* 25.09-41.98 MET-hr/week: HR = 0.83 (95%CI 0.46-1.49)
* >41.99 MET-hr/week: HR= 1.01 (95%CI 0.61-1.68)
 |
| Perera 2018 | NR | * Psychiatric inpatient with history of SA, likelihood to engage in mild PA vs sedentary: OR = 0.35 (95%CI 0.16-0.76)
* Psychiatric inpatient, no history of SA, likelihood to engage in mild PA vs sedentary: OR = 0.56 (95%CI 0.24-1.30)
* Community control, no history of SA, likelihood to engage in mild PA vs sedentary: OR = 0.12 (95%CI 0.04-0.39)
* Psychiatric inpatient with history of SA, likelihood to engage in moderate/strenuous PA vs sedentary: OR = 0.42 (95%CI 0.19-0.95)
* Psychiatric inpatient, no history of SA, likelihood to engage in moderate/strenuous PA vs sedentary: OR = 0.96 (95%CI 0.38-2.45)
* Community control, no history of SA, likelihood to engage in moderate/strenuous PA vs sedentary:OR =0.15 (95%CI 0.05-0.48)
 | * NR
 |
| Simon 2004 | NR | * Primary PA: Reference
* No primary physical activity: OR = 6.06 (95%CI 2.83-12.95)
 | * NR
 |
| Kang 2013 | * Inactive (those who initially did not have SI but developed SI in follow-up): OR = 1.09 (95%CI 0.61-1.94)
 | * NR
 | * NR
 |
| Kikuchi 2009 | NR | NR | *Walking <1 hour/day** No pain: HR = Reference
* Very mild pain: HR = 1.69 (95%CI 0.52-5.53)
* Mild pain: HR = 3.02 (95%CI 0.95-9.6)
* Severe pain: HR = 4.47 (95%CI 1.30-15.35)

*Walking ≥1 hour/day* * No pain: HR = Reference
* Very mild pain: HR = 1.11 (95%CI 0.40-3.04)
* Mild pain: HR = 1.86 (95%CI 0.68-5.08)

Severe pain: HR = 2.12 (95%CI 0.67-6.74) |
| Perez 2022 | Participants with MDD and risk of low SI:Light standing PA: OR = 1.01 (95%CI 1.00-1.03)Light ambulatory PA: OR = 0.96 (95%CI 0.92-1.01)Moderate-to-vigorous PA: OR = 1.01 (95%CI 0.94-1.08)Participants with MDD and risk of moderate/high SI:Light standing PA: OR = 1.01 (95%CI 1.00-1.03)Light ambulatory PA: OR = 0.98 (95%CI 0.94-1.02)Moderate-to-vigorous PA: OR = 1.02 (95%CI 0.96-1.08)Participants currently experiencing a MDE and risk of low SI:Light standing PA: OR = 1.03 (95%CI 1.00-1.06)Light ambulatory PA: OR = 0.910 (95%CI 0.84-0.98)Moderate-to-vigorous PA: OR = 1.07 (95%CI 0.95-1.20)Participants currently experiencing a MDE and risk of moderate/high SI:Light standing PA: OR = 1.03 (95%CI 1.00-1.06)Light ambulatory PA: OR = 0.92 (95% CI 0.85-1.00)Moderate-to-vigorous PA: OR = 1.12 (95%CI 0.99-1.26) | NR | NR |

*Abbreviations: not reported (NR), odds ratio (OR), hazard ratio (HR), suicide attempt (SA), major depressive disorder (MDD), major depressive episode (MDE), suicidal ideation (SI), physical activity (PA)*

**Table 3: NIH Quality Assessment for Cohort Studies**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Study** | **Meerwijk 2022** | **Mukamal 2007** | **Kang 2013** | **Kikuchi 2009** | **Perez 2022** |
| 1. Was the research question or objective in this paper clearly stated? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2. Was the study population clearly specified and defined? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3. Was the participation rate of eligible persons at least 50%? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 5. Was a sample size justification, power description, or variance and effect estimates provided? | ✘ | ✓ | ✓ | ✓ | ✘ |
| 6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? | ✓ | ✓ | ✘ | ✓ | ✓ |
| 10. Was the exposure(s) assessed more than once over time? | ✓ | ✓ | ✓ | ✘ | ✘ |
| 11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? | ✓ | ✓ | ✓ | ✓ | ✓ |
| 12. Were the outcome assessors blinded to the exposure status of participants? | ✘ | ✓ | ✘ | **?** | **?** |
| 13. Was loss to follow-up after baseline 20% or less? | ✓ | ✓ | ✘ | ✓ | ✓ |
| 14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Total** | 12/14 | 14/14 | 11/14 | 12/14 | 12/14 |

Legend: Yes (✓), No (✘), Unclear (**?**)

**Table 4: NIH Quality Assessment for Case-Control Studies**

|  |  |  |
| --- | --- | --- |
| **Study** | **Perera 2018** | **Simon 2004** |
| 1. Was the research question or objective in this paper clearly stated and appropriate? | ✓ | ✓ |
| 2. Was the study population clearly specified and defined? | ✓ | ✓ |
| 3. Did the authors include a sample size justification? | ✓ | ✘ |
| 4. Were controls selected or recruited from the same or similar population that gave rise to the cases (including the same timeframe)? | ✓ | ✓ |
| 5. Were the definitions, inclusion and exclusion criteria, algorithms or processes used to identify or select cases and controls valid, reliable, and implemented consistently across all study participants? | ✓ | ✓ |
| 6. Were the cases clearly defined and differentiated from controls? | ✓ | ✓ |
| 7. If less than 100 percent of eligible cases and/or controls were selected for the study, were the cases and/or controls randomly selected from those eligible? | ✘ | ✓ |
| 8. Was there use of concurrent controls? | **?** | **?** |
| 9. Were the investigators able to confirm that the exposure/risk occurred prior to the development of the condition or event that defined a participant as a case? | ✓ | ✓ |
| 10. Were the measures of exposure/risk clearly defined, valid, reliable, and implemented consistently (including the same time period) across all study participants? | ✓ | ✓ |
| 11. Were the assessors of exposure/risk blinded to the case or control status of participants? | ✓ | ✘ |
| 12. Were key potential confounding variables measured and adjusted statistically in the analyses? If matching was used, did the investigators account for matching during study analysis? | ✘ | **?** |
| **Total** | 9/12 | 8/12 |

Legend: Yes (✓), No (✘), Unclear (**?**)