SYSTEMATIC REVIEW

Apathy and Physical Activity: A Systematic Review and Meta-Analysis

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ABSTRACT

Purpose: Patient motivation is essential for successful rehabilitation, so apathy may hinder physiotherapists' interventions aimed at increasing physical activity. We examined the relationship between apathy and physical activity to identify the factors that influence it. ***Methods:*** Pearson product-moment correlations were pooled from eligible studies to examine the relationship between apathy and physical activity. Subgroup meta-analyses and meta-regressions were also conducted. ***Results:*** From the systematic review (28 articles) and main meta-analysis (22 studies; $N = 12{,}541$), the results showed a negative correlation between apathy and physical activity ($r = -0.13$; 95% CI: -0.18, -0.09; $p < 0.0001$ based on Pearson's r-values; $r = -0.40$; 95% CI: -0.68, -0.02; $p = 0.043$ based on Spearman's ρ-values). The correlation was statistically significant in patients with Parkinson's disease and in older adults who were healthy, depressed, fallers, or had mild cognitive impairment. A meta-regression showed an effect of age, with a stronger correlation between apathy and physical activity in older adults compared to younger adults ($p = 0.003$). ***Conclusion:*** Higher levels of apathy are associated with lower levels of physical activity, and this negative association is stronger with age. Therefore, apathy may limit exercise therapy efficacy and carry prognostic implications for patients whose condition requires physical activity.

Key Words: exercise; geriatrics; health; motivation.

RÉSUMÉ

Objectif : la motivation des patients est essentielle au succès de leur rééducation. L'apathie peut donc entraver les interventions des physiothérapeutes visant à augmenter l'activité physique. Nous avons examiné la relation entre l'apathie et l'activité physique afin d'identifier les facteurs qui l'influencent. ***Méthodologie :*** les corrélations produit-moment de Pearson des études éligibles ont été regroupées afin d'étudier la relation entre l'apathie et l'activité physique. Des méta-analyses et des méta-régressions ont également été réalisées. ***Résultats :*** la revue systématique (28 articles) et la méta-analyse principale (22 études ; 12 541 participants) ont montré une corrélation négative entre l'apathie et l'activité physique ($r = -0{,}13$; IC à 95% : $-0{,}18$, $-0{,}09$; $p < 0{,}0001$ sur la base des valeurs r de Pearson ; $r = -0.40$; IC à 95% : -0.68, -0.02 ; $p = 0.043$ sur la base des valeurs ρ de Spearman). La corrélation était statistiquement significative chez les patients atteints de la maladie de Parkinson et chez les personnes âgées en bonne santé, dépressives, sujettes aux chutes ou présentant une déficience cognitive légère. Une méta-régression a montré un effet de l'âge, avec une corrélation plus forte entre l'apathie et l'activité physique chez les personnes âgées que chez les adultes plus jeunes ($p = 0{,}003$). ***Conclusion :*** des niveaux d'apathie plus élevés sont associés à des niveaux d'activité physique plus faibles, et cette association négative se renforce avec l'avancée en âge. Par conséquent, l'apathie pourrait limiter l'efficacité de la thérapie par l'exercice et avoir des implications pronostiques chez les patients dont l'état nécessite une activité physique.

Mots-clés : exercice; gériatrie; gérontologie; santé; motivation.

LAY SUMMARY

The motivation required to adhere to prescribed rehabilitation exercises may be impaired in patients with apathy. In our meta-analysis of 12,541 participants, higher levels of apathy were associated with lower levels of physical activity. This detrimental association was greater in older adults. These findings suggest that apathy should be considered when developing strategies for regular exercise as it may impact the recovery of patients requiring physical activity.

RÉSUMÉ NON SCIENTIFIQUE

La motivation requise pour suivre assidument des prescriptions d'exercices de rééducation peut être réduite chez les patients souffrant d'apathie. Dans notre méta-analyse portant sur 12 541 participants, des niveaux plus élevés d'apathie étaient associés à des niveaux plus faibles d'activité physique. Cette association néfaste était plus importante chez les adultes plus âgés. Ces résultats suggèrent que l'apathie devrait être prise en compte lors du développement de stratégies d'exercice régulier car elle pourrait avoir un impact sur la récupération des patients nécessitant de l'activité physique.

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Psychological factors are essential to quality rehabilitation interventions.[1] Motivation, for example, defined as the hypothetical construct used to describe the internal and external forces that produce the initiation, direction, intensity, and persistence of behaviour,[2] is a parameter that physiotherapists should consider in their intervention, as it influences the patient's ability to adhere to the prescribed rehabilitation programme.[3] While motivation can vary within a physiological range, a patient's pathology can also alter it, leading to ineffective care.[4] An example of such alteration is apathy, which is conceptualized as a behavioural disorder.[5,6]

In the early 1990s, studies began to consider apathy a syndrome rather than a mere symptom of another condition, redefined as a state of primary motivational impairment characterized by reduced goal-directed behaviours (e.g., lack of productivity, effort, initiative, and perseverance), reduced goal-directed cognitions (e.g., lack of interest in learning new things, in new experiences, lack of concern about one's personal and health problems, reduced socialization), and reduced emotional concomitances of behaviour (e.g., flat affect, emotional indifference).[5,6] To date, the dominant theoretical frameworks still consider three subtypes of apathy: behavioural, cognitive, and emotional.[7,8] Levy and Dubois[9] proposed that behavioural apathy is related to difficulties in elaborating the plan of actions necessary for behaviour. Cognitive apathy is the inability to self-activate thoughts or self-initiate actions. Emotional apathy is the inability to establish the linkage between emotional signals and behaviour.[9] Dickson and Husain have recently proposed a fourth subtype, social apathy, but further research is required.[10]

Apathy occurs across a wide range of neurological and psychiatric disorders,[11] including dementia (54%),[12] schizophrenia (47%–53%),[13–15] Parkinson's disease (40%),[16] and stroke (33%).[17] Studies have also observed apathy in healthy young adults (1.5%)[18] and older adults with normal cognitive function (2%–7%).[19–23] Apathy is associated with lower cognitive performance in older adults with normal cognitive functioning,[20] cognitive decline (mild cognitive impairment),[21] transition to dementia,[24,25] and dementia severity.[26,27] Therefore, some studies consider apathy a marker of impending cognitive decline and future risk for dementia.[20] Others associate apathy with frailty,[26] functional decline,[27–30] poorer quality of life,[18,23,31] higher mortality,[32,33] and higher health care costs.[34]

In addition, some studies suggest that apathy can negatively affect physical activity,[27–40] which includes exercise, sports, active travel (cycling, walking), household chores, and work-related physical activity.[41] This potential effect of apathy is worth investigating since research now widely recognizes physical activity as one of the top contributors to physical and mental health, improving cognitive functioning,[42] and reducing rates of cardiovascular disease,[43] cancer,[44] hypertension,[45] diabetes,[46] obesity,[47] depression,[48] and functional dependence.[48–50] Despite these benefits, one in four adults fails to meet the recommended levels of physical activity.[41] While the motivational impairment that defines apathy is likely to reduce the engagement in physical activity, there are some discrepancies in the literature, with multiple articles showing no evidence of such a relationship[51,52] or even supporting the opposite association.[53]

The main objective of this study was to conduct a systematic review and meta-analysis of the direct relationship between apathy and physical activity. We hypothesized that levels of apathy would be negatively associated with levels of physical activity. Since studies assessing this relationship used different methods and outcome measures in a variety of health conditions, we explored whether apathy measure, physical activity measure (e.g., accelerometers, pedometers, questionnaires), physical activity outcome (e.g., total physical activity, moderate or vigorous physical activity, steps per day), and health status influenced the results. Additionally, since reduced physical activity[54] and higher apathy[55,56] are associated with older age and being a woman, we explored whether these demographics influenced the results.

METHODS

Search strategy

This review is in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[57] We identified potential studies by searching the MEDLINE (via PubMed), PsycINFO, Web of Science, Embase, SPORTDiscus, and CINAHL databases. The search terms used to identify relevant studies were variants of physical activity (e.g., physical activity, physical education, training, physical fitness, exercise, sport, walk) and apathy (e.g., abulia, apathetic, amotivation, avolition, neuropsychiatric inventory, NPI [NeuroPsychiatry Inventory], emotional indifference, Frontal Lobe Personality Scale, Lille Apathy Rating Scale [LARS], dementia apathy interview and rating, Dementia Apathy Interview and Rating [DAIR], Frontal System Behaviour Scale [FrSBe], Key Behaviours Change Inventory [KBCI], Apathy Evaluation Scale, Apathy Scale, and Irritability Apathy Scale [online Appendix 1]). We searched articles up to October 10, 2023, with no limitation on the start date, and used a filter to limit the search to studies published in English. To reduce literature bias, we pre-registered this systematic review in PROSPERO (CRD42023492162).[58]

Eligibility criteria and study selection

Inclusion criteria

To be included in this systematic review, articles had to (1) be published in a peer-reviewed journal, (2) be written in English, (3) report original data collected from human participants, (4) include at least one self-reported measure of apathy and at least one measure of physical activity, and (5) formally test the association between these two variables (e.g., reporting Pearson's r or Spearman's ρ correlation coefficient). The physical activity measure could be a self-reported measure or device-based measure (e.g., accelerometry) of the level of physical activity. We included cohort studies, baseline data from clinical trials, and cross-sectional studies in this review. The inclusion criteria did not impose any specific age or gender restrictions.

Exclusion criteria

We excluded studies if they were (1) published as a book chapter, study protocol, or conference abstract, or (2) based on laboratory-based measures of physical fitness (e.g., maximal muscle force, $\dot{V}O_2$ max) and not on a measure of physical activity.

Study selection

We screened the articles using the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia), a web-based collaborative software platform that streamlines the production of systematic reviews. After removing duplicates, two reviewers who authored this article (AF, AH) independently reviewed the titles and abstracts according to the inclusion and exclusion criteria. If there was any doubt about the inclusion or exclusion of an article, the reviewers read the full text. In addition, we performed reference screening and forward citation tracking on the included articles. We resolved disagreements between the two reviewers by consensus among four reviewers (AF, AH, MB, MPB).

Data extraction

Data extracted from the selected articles included first author's name, article title, publication year, number of participants, number of men and women, mean age and range, health status, type of apathy measure, level of apathy, type of physical activity measure and outcome, level of physical activity, as well as statistical estimates, and significance of the association between apathy and physical activity. We developed the data extraction form and previously tested it in a systematic review.[59,60]

Bias assessment

We assessed the included studies for methodological quality using 10 questions from the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.[61] Two reviewers (AF, AH) independently answered these questions for each study, with a third reviewer (MPB) involved in case of disagreement.

Meta-analysis

We conducted all analyses in RStudio integrated development environment (IDE) (2023.06.1+524, "Mountain Hydrangea" release) for R software environment[62] using the *meta*,[63] *metasens*,[64] and *metafor*[65,66] R packages.

Main meta-analysis

In the main meta-analysis, we pooled Pearson product-moment correlations from eligible studies to examine the relationship between apathy and physical activity. When a correlation coefficient was not reported, but the exact p-value (or t-value) and sample size were available, and it was possible to know the sign of the correlation, we computed the Pearson's r-value using an ad-hoc R code (online Appendix 3) using the "qt" function of the R "MASS" package to find the critical value of t.[67,68] For the studies that reported a relative p-value < 0.001 instead of an exact p-value, we used a p-value of 0.0009 to estimate an approximate r-value. When an article did not report exact p-values but the sample size (n) and Pearson's correlation coefficient were available, we computed the exact p-value using an ad-hoc R code (online Appendix 4). We pooled correlations using the generic inverse pooling method via the "metacor" function in the R *meta* package.[63] This function automatically performs a necessary Fisher's z-transformation on the original, untransformed correlations prior to pooling. The "metacor" function reconverts the pooled association back to its original form for ease of interpretation. We anticipated considerable between-study heterogeneity and therefore used a random-effects model to pool correlations. We used the restricted maximum likelihood estimator[69] to calculate the heterogeneity variance τ^2. In addition to τ^2, to quantify between-study heterogeneity, we report the I^2 statistic, which provides the percentage of variability in the correlations that is not caused by sampling error.[70] We interpreted the I^2 statistic as follows: 0%–40%, may not be important; 30%–60%, may represent moderate heterogeneity; 50%–90%, may represent substantial heterogeneity; and 75%–100%, may represent considerable heterogeneity. To reduce the risk of false positives, we used a Knapp-Hartung adjustment[71] to calculate the confidence interval around the pooled association. We also report the prediction interval, which provides a range within which we can expect the associations of future studies to fall based on the current evidence. If significant, we interpreted the pooled correlation using Cohen's conventions:[72] $r \approx -0.10$, small negative correlation; $r \approx -0.30$, moderate negative correlation; $r \approx -0.50$, large negative correlation.

Publication bias assessment

Publication bias refers to the fact that studies with positive or significant results are more likely to be published, while studies with negative or non-significant results are less likely to appear in the literature. Therefore, publication bias can affect the validity and generalization of conclusions of a meta-analysis.[73] Here, we assessed publication bias using a funnel plot, which is a scatter plot of the studies' effect size expressed as the Fisher's z-transformed correlation on the x-axis against a measure of their standard error (which is indicative of precision of the study's effect size) on the y-axis. We also used Egger's regression to formally test funnel plot's asymmetry.[74] Because the probability of obtaining significant results rises with a larger sample size, publication bias will disproportionately affect small studies. Rücker's limit meta-analysis method explicitly accounts for the publication bias due to small studies,[75] so we used it to compute a bias-corrected estimate of the true effect size. More specifically, the model underlying Rücker's method is an extended random-effects model that takes account of possible small study effects by allowing the tested effect to systematically depend on the standard error (online Appendix 2).

Another method used to assess publication bias was p-curve analysis.[76] When the null hypothesis is true (i.e., there is no true effect), p-values are assumed to follow a uniform distribution: Highly significant effects (e.g., $p = 0.01$) are as likely as barely significant effects (e.g., $p = 0.049$). However, when the null hypothesis is false (i.e., there is a true effect in our data), p-values are assumed to follow a right-skewed distribution: Highly significant effects are more likely than barely significant effects. A left-skewed distribution would suggest that some studies used statistical tests to find significant results in ways that may not be reproducible or generalizable (i.e., p-hacking).

Secondary meta-analysis

We conducted a secondary meta-analysis using the same approach as described in the main meta-analysis, but based on Spearman's ρ values, to further test the relationship between apathy and physical activity. We chose not to compare r and ρ values, or any transformed versions of them in the same meta-analysis, because they do not reflect the same property of the data. In the secondary meta-analysis, some studies reported multiple outcomes for the same sample of participants. Therefore, we nested correlation estimates within studies using the "cluster" argument to account for the dependencies between these estimates, resulting in a three-level meta-analysis (level 1: participants, level 2: correlation estimates, level 3: studies). We assessed the distribution of variance across levels using the multilevel version of I^2,[77] and assessed and compared the performance of the two-level and three-level meta-analyses using the *metafor* R package.[65,66]

Subgroup meta-analyses and meta-regressions

We examined subgroup meta-analyses on the differences in correlations between studies that included participants with different health conditions, used different types of physical activity outcomes, and used different types of apathy measures.

We also examined meta-regressions on whether the average age of participants or the proportion of women in a study predicted the reported correlation between apathy and physical activity. We used another meta-regression as a sensitivity analysis to examine whether the quality of the studies affected the correlation.

RESULTS

Literature search

The primary search identified 6,950 potentially relevant articles from the six databases (Figure 1), including 2,025 duplicates. Of the 4,925 articles screened, 3,441 were unrelated to apathy or physical activity. Of the remaining 1,484 articles, 65 met the criteria for further investigation and potential inclusion. To increase the completeness of our review, we emailed the corresponding authors of 42 articles that did not formally test the association between apathy and physical activity to request the correlation estimate or raw data so we could compute this estimate ourselves. Six authors replied: one provided raw data,[78] one provided the Pearson's correlation coefficient,[79] and four replied that they would contact their co-authors but did not get back to us.[80–83] Reference screening and forward citation tracking identified three additional studies,[84–86] of which one provided the Pearson correlation upon request.[84] We provide detailed reasons for exclusion at each stage in the PRISMA flow diagram (Figure 1). Ultimately, we included 28 articles in the systematic review. Two of these articles, published by the same group, had similar methods and partly overlapping recruitment periods, suggesting that some participants may have been included in both studies.[52,87] Quality score of studies ranged from 6 to 10 out of 10, with a mean 8.4 (SD 1.2) (Table 1).

Descriptive results

Participants

The 28 articles identified by the systematic review included a total of 13,716 participants aged 30 to 95 years, including 7,167 women, 6,283 men, and 266 participants whose gender and sex were not reported. The studies investigated populations with stroke ($k = 4$),[52,53,87,88] multiple sclerosis ($k = 1$),[3] Parkinson's disease ($k = 6$),[40,84,86,89–91] mental illness ($k = 2$),[92,93] cancer ($k = 1$),[94] myotonic dystrophy ($k = 1$),[51] Alzheimer's disease ($k = 1$),[39] depression ($k = 3$),[85,95,96] cognitive impairment ($k = 3$),[78,79,97] as well as healthy older adults ($k = 9$)[38,95–102] (Table 1).

Apathy

In 14 of the 28 studies, researchers assessed apathy using the Apathy Scale ($k = 13$)[40,52,84–87,89–91,94–96,100] or its

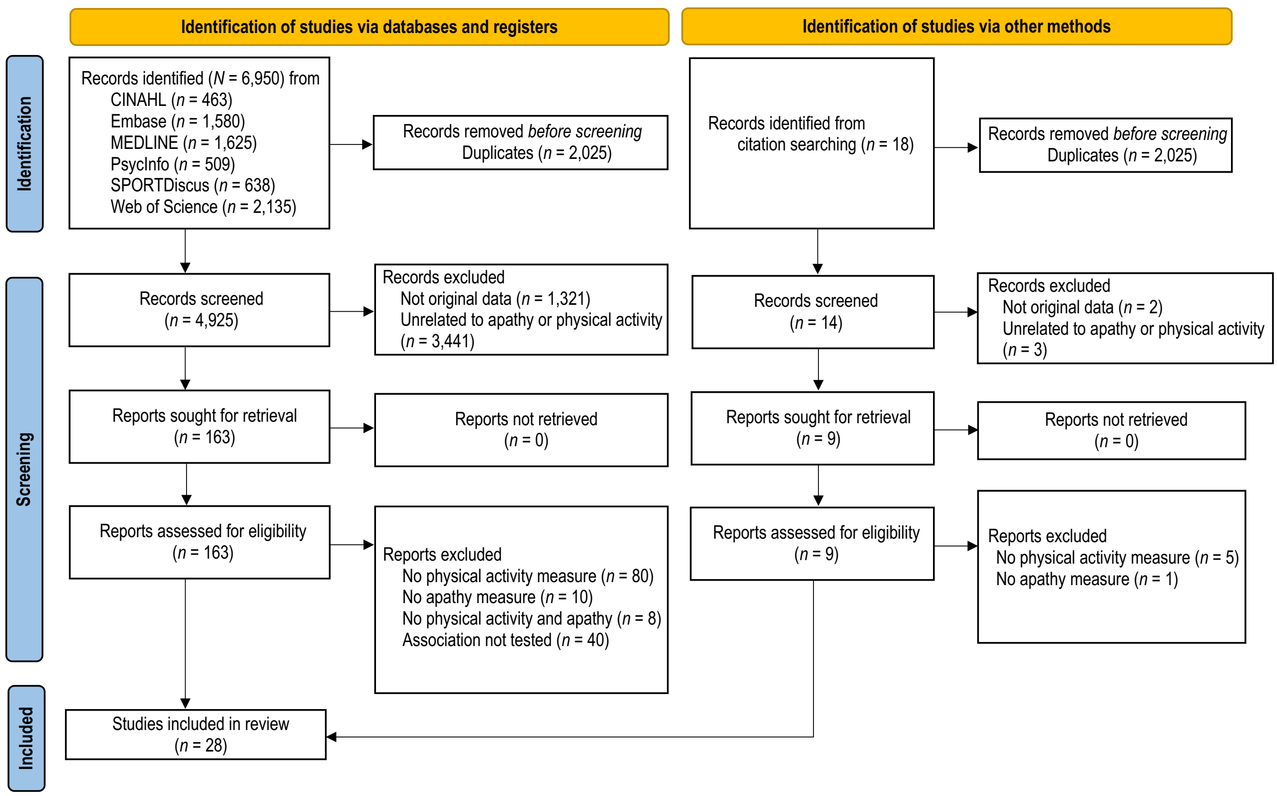

Figure 1 PRISMA 2020 flow diagram.
Figure 1 Extended Description

shorter version (12-item Apathy Scale [$k = 1$]).[38] This scale consists of 14 questions rated on a Likert scale ranging from 0 (not at all) to 3 (a lot). The total score on the 14-item Apathy Scale ranges from 0 to 42, with higher scores indicating more severe apathy. In clinical settings, a patient with a score $\geq$ 16 is considered apathetic.[103] Studies also assessed apathy using the Apathy Evaluation Scale ($k = 6$)[37,51,53,79,88,93] or its shorter version [12-item Apathy Evaluation Scale ($k = 1$)].[92] This scale consists of 18 items assessing the cognitive, emotional, and behavioural aspects of apathy, rated on a Likert scale ranging from 1 (not at all) to 4 (a lot). The total score ranges from 18 to 72, with higher scores indicating more severe apathy. In a clinical setting, a patient with a score $\geq$ 37 is considered apathetic.[104] The other measures that researchers used are the apathy subscale of the Geriatric Depression Scale ($k = 4$)[98,99,101,102] and the apathy subscale of the Neuropsychiatric Inventory Questionnaire ($k = 3$).[39,78,97]

Eighteen studies reported mean levels of apathy (Table 1). The Apathy Scale-based studies revealed a range from 8.7[40] to 27.8,[84] while the Apathy Evaluation Scale studies reported levels between 13.0[51] and 31.4.[53]

Physical activity

Twenty-four studies assessed physical activity using a self-reported measure (Table 1). Five of these questionnaire-based studies used the short form of the International Physical Activity Questionnaire (IPAQ-SF),[51,53,78,89,92] which consists of six items assessing time spent in light (i.e., walking), moderate (e.g., carrying light loads, cycling at moderate speed, doubles tennis), and vigorous physical activity (e.g., digging, fast cycling, heavy lifting, aerobics) over the last seven days.[105] The other questionnaires used to assess physical activity were the long form version of the IPAQ (IPAQ-LF) ($k = 4$),[85,86,95,96] the modified Baecke Habitual Physical Activity Questionnaire (BHPAQ) ($k = 2$),[38,100] the Minnesota Leisure Time Physical Activity Questionnaire ($k = 1$),[86] the Longitudinal Aging Study Amsterdam Physical Activity Questionnaire (LAPAQ) ($k = 1$),[99] the National Health Interview Survey and the Minnesota Heart Survey Physical Activity Questionnaire (NHIS/MHS PAQ) ($k = 1$),[97] the Nurses' Health Study II Activity and Inactivity Questionnaire (NHST II Activity) ($k = 1$),[94] the Physical Activity Disability Scale (PADS) ($k = 1$),[37] the Nord-Trøndelag Health Study-derived questions (HUNT) ($k = 2$),[88,93] the Canadian Community Health Survey-derived questionnaire (CCHS) ($k = 1$),[84] and the Physical Activity Scale for the Elderly (PASE) ($k = 1$).[40]

The studies also assessed physical activity with devices such as accelerometers measuring accelerations in three dimensions ($k = 4$)[39,51,79,92] and pedometers measuring the number of steps ($k = 3$)[52,53,87] (Table 1). Participants wore these devices at the hip ($k = 2$),[51,53] chest ($k = 1$),[79]

Table 1 Characteristics of the studies included in the systematic review

First author (Year)	*n* (no. of women)	Mean (SD) age, y	Health status	Mean (SD) apathy*	Mean (SD) physical activity*	Correlation	*p*-value	Quality score
Abrantes (2012)[89]	45 (15)	66.1 (7.6)	Parkinson's disease	10.7 (6.8; AS)	n.a. (IPAQ-SF)	$r = -0.25$	$0.098^{\ddagger}$	9
Ayari (2023)[78]	23 (16)	78 (7)	Cognitive impairment	0.17 (NPI-apathy subscale)	451.08 MET-min/wk (IPAQ-SF)	$r = -0.48$	$0.020^{\ddagger}$	9
Ersöz Hüseyinsinoğlu (2017)[53]	85 (35)	64.7 (10.2)	Stroke	31.4 (11.9; AES)	2646.5 (1235.6; daily step; pedo.) 1.8 (1.0 distance count; pedo.) 425.9 (541; MET-min/wk; IPAQ-SF)	$\rho = -0.15$ $\rho = 0.01$ $\rho = -0.11$	0.42 0.92 0.29	10
Farholm (2017)[92]	106 (65)	45.7 (11.9)	Mental illness	n.a. (S-AES)	39.3(52.3, min/d; IPAQ-SF) 44.9(34.2; min/d; wrist accelero.)	$\rho = -0.49$ $\rho = -0.39$	<0.001 <0.01	9
Friedmann (2014)[79]	40 (29)	80.72 (9.3)	Cognitive impairment	17.1 (0.6; AES)	107.4 (10.4; kcal/d; chest accelero.)	$r = -0.04^{\dagger}$	0.821	10
Gorzkowska (2020)[86]	134 (61)	65.2 (9.2)	Parkinson's disease	n.a. (AS)	n.a. (IPAQ, MLTPAQ)	n.a.	<0.05	9
Groeneweg-Koolhoven (2016)[85]	266 (n.a.)	n.a. (>60)	Depressed older adults	n.a. (AS)	n.a. (IPAQ)	$B = -0.9$ $\beta = -0.1$ OR = 0.5 $r = -0.12^{\dagger}$	0.05	9
Grool (2014)[101]	4354 (2548)	76 (5.4)	Older adults	n.a. (dichotomized; GDS-apathy subscale)	n.a. (ad-hoc questionnaire)	$r = -0.05^{\dagger}$	<0.001	7
Hamre (2021)[88]	101 (21)	55.5 (11.4)	Stroke	28.0 (7.8; AES)	2.1 (0.3; HUNT-derived questions)	$B = -0.02$ $r = -0.32^{\dagger}$	0.001	10
Hashimoto (2017)[100]	213 (114)	68.9 (7.5)	Older adults	n.a. (AS)	n.a. (modified BHPAQ) Leisure (5-point scale) work (5-point scale) sport (< vs. ≥ 4 MET-h/wk)	 OR = 0.59 n.a. n.a.	 <0.05 >0.05 >0.05	6
Henstra (2018)[98]	243 (161)	75.8 (7.0)	Older adult fallers	n.a. (dichotomized; GDS-apathy subscale)	n.a. (ad-hoc questionnaire)	$r = -0.15^{\dagger}$	0.016	9
Henstra (2019)[95]	380 (247)	69 (11)	Healthy and depressed older adults	n.a. (dichotomized; AS)	2231 (1989; MET-min/wk; IPAQ)	$B = -59.8$ $r = -0.17^{\dagger}$	<0.001	6
Henstra (2019)[99]	2893 (1416)	73.3 (6.6)	Older adults	n.a. (dichotomized; GDS-apathy subscale)	135.4 (80.8; LAPAQ)	$r = -0.06^{\dagger}$	<0.001	10
Henstra (2022)[96]	394 (278)	69.3 (6.9)	Healthy and depressed older adults	n.a. (AS)	n.a. (IPAQ; low vs. moderate vs. high)	$r = -0.17^{\dagger}$	<0.001	6
Ishimaru (2020)[39]	43 (35) 20 (14)	90.2 (6.4) 87.5 (6.1)	Severe Alzheimer's Moderate Alzheimer's	n.a. (NPI-Apathy subscale) n.a. (NPI-Apathy subscale)	73.5 (39.1; counts/min; wrist accelero.) 92.1 (27.9; counts/min; wrist accelero.)	$\rho = -0.71$ n.a.	>0.05 >0.05	9
Ito (2020)[87]	60 (22)	63.7 (14.4)	Stroke	n.a. (dichotomized; AS)	5772(2805; daily steps; pedo.)	$r = -0.32^{\dagger}$	0.013	7
Ito (2021)[52]	101 (36)	64.5 (13.5)	Stroke	10.6 (6.7; AS)	6184 (2914; daily steps; pedo.)	$B = 0.48$ $\beta = 0.05$ $r = 0.05^{\dagger}$	0.64	8
Knak (2020)[51]	67 (32)	41 (10)	Myotonic dystrophy	13 (15.9; AES)	485(144; min/wk; hip accelero.) 441(382; min/wk; IPAQ-SF)	$\beta = -4.36$ $r = -0.17^{\dagger}$	0.16 n.a.	8
Krell-Roesch (2023)[97]	3222 (1433)	79.2 (65.6)	Healthy and MCI older adults	188 (6; NPI-Apathy subscale)	6.5 (3.9) (NHIS/MHS PAQ)	OR = 0.89 $r = -0.32^{\dagger}$	<0.001	8

(*Continued*)

Table 1 Continued

First author (Year)	*n* (no. of women)	Mean (SD) age, y	Health status	Mean (SD) apathy*	Mean (SD) physical activity*	Correlation	*p*-value	Quality score
Lemij (2023)[94]	239 (239)	74.7 (4.4)	Cancer	n.a. (AS)	28.9 (35; MET-h/wk; NHST II)	$\beta = -0.43$ $r = -0.08^{\dagger}$	0.236	9
Miura (2014)[91]	32 (22)	67.8 (7.4)	Parkinson's disease	n.a. (AS)	n.a. (dichotomized; ad-hoc questions)	$r = -0.12^{\dagger}$	0.510	7
Ng (2021)[40]	121 (47)	64.48 (8.2)	Parkinson's disease	8.7 (6.28; AS)	161.2 (89.5; PASE)	$r = -0.23$	$0.011^{\ddagger}$	8
Ringen (2018)[93]	83 (26)	40 (11.7)	Mental illness	22.0 (6.4; AES)	3.5 (2.7; h/wk; HUNT questions)	$r = -0.24^{\dagger}$	0.028	10
Rios Romenets (2015)[84]	33 (14)	63.8 (9.2)	Parkinson's disease	27.8 (7.4; AS)	n.a. (yes vs. no; CCHS questions)	$\rho = -0.31$	>0.05	10
					n.a. (h/wk; CCHS derived questions)	$r = -0.18$	$0.316^{\ddagger}$	
Sacheli (2018)[90]	17 (4)	62.7 (6.1)	Parkinson's disease	7.8 (2.9; AS)	Active: 476.3 (63.1; diary min/wk)			
		68.8 (4.7)	Parkinson's disease	15.5 (7.1; AS)	Sedentary: 104.2 (63.1; diary min/week)	$r = -0.40^{\dagger}$	$0.011^{\ddagger}$	8
Talamonti (2022)[102]	41 (26)	66.93 (5.3)	Healthy older adults	n.a. (GDS-apathy subscale)	n.a. (dichotomized; ad-hoc questions)	$r = -0.25$	0.67	7
Vanner (2008)[37]	43 (31)	53.7 (10.2)	Multiple sclerosis	30.8 (9.3; AES)	10.6 (57.9; PADS)	$r = -0.278$	0.071	9
Yao (2015)[38]	317 (180)	64.5 (10.2)	Healthy older adults	467 (113; AS)	n.a. (modified BHPAQ)			8
					Leisure (5-point scales)	$\beta = -0.25$	<0.001	
					work (5-point scales)	$\beta = -0.05$	>0.05	
					sport (dichotomized; MET-h/wk)	$\beta = -0.09$	>0.05	

accelero. = accelerometer; AES = Apathy Evaluation Scale; AS = Apathy Scale; B = unstandardized regression coefficient; BHPAQ = Baecke questionnaire on Habitual Physical Activity; CCHS = Canadian Community Health Survey; GDS = Geriatric Depression Scale; HUNT = Nord-Trøndelag Health Study; IPAQ = International Physical Activity Questionnaire; LAPAQ = Longitudinal Aging Study Amsterdam Physical Activity Questionnaire; MCI = Mild Cognitive Impairment; MLTPAQ = Minnesota Leisure Time Physical Activity Questionnaire; n.a. = not available; NHIS/MHS PAQ = National Health Interview Survey and the Minnesota Heart Survey Physical Activity Questionnaire; NHST II = Nurses' Health Study II Activity and Inactivity Questionnaire; NPI = Neuropsychiatric Inventory Questionnaire; PADS = Physical Activity Disability Scale; PASE = Physical Activity Scale for the Elderly; pedo. = pedometer, r = Pearson's correlation coefficient; S-AES = Short Apathy Evaluation Scale; β = standardized regression coefficient; ρ = Spearman's correlation coefficient.

* Unless otherwise noted.

†When Pearson's correlation coefficient (r) was not reported in an article, but the exact p-value and sample size (n) were available and it was possible to know the sign of the correlation based on the information provided in the article, the r-value was computed using an ad-hoc R code.

‡When exact p-values were not reported in an article, but the sample size (n) and Pearson's correlation coefficient r were available, the exact p-value was computed using an ad-hoc R code. For the studies that reported a relative p-value < 0.001 instead of an exact p-value, we used a p-value of 0.0009 to estimate an approximate r-value.

Table 2 Results of the main, secondary, and subgroup meta-analyses

Characteristics	*k*	*N*	cor.	95% CI	I^2 (%)	*p*-value
Main: Pearson's *r*-values						<0.0001
Apathy and physical activity	22	12,541	−0.13	−0.18, −0.09	49	
Main: Rücker's limit method						0.0065
Apathy and physical activity	22	12,541	−0.08	−0.14, −0.02	49	
Secondary: Spearman's ρ values						0.043
Apathy and physical activity	4	543	−0.40	−0.68, −0.02	82	
Subgroup: Health status						<0.0001
Older adults (healthy, depression, falls, or MCI)	10	11,599	−0.10	−0.15, −0.05	50	
Parkinson's disease	5	248	−0.22	−0.31, −0.14	0	
Stroke	3	262	−0.20	−0.64, 0.34	9	
Cancer	1	239	−0.08	−0.20, 0.05		
Severe mental illness	1	83	−0.24	−0.43, −0.03		
Myotonic dystrophy	1	67	−0.17	−0.39, 0.07		
Multiple sclerosis	1	43	−0.27	−0.53, 0.03		
Subgroup: Physical activity outcome						<0.0001
Score	7	6,398	−0.14	−0.23, −0.04	56	
MET-min/wk	6	1,347	−0.15	−0.22, −0.08	0	
Active time	5	241	−0.22	−0.30, −0.14	0	
Steps/d	2	161	−0.13	−0.99, 0.98	81	
Frequency	1	4,354	−0.05	−0.08, −0.02		
Kcal/day	1	40	−0.03	−0.34, 0.28		
Subgroup: Apathy measure						<0.0001
Apathy Scale (AS)	11	1,688	−0.15	−0.20, −0.10	0	
Apathy Evaluation Scale (AES)	5	334	−0.23	−0.35, −0.11	0	
GDS	4	12,541	−0.06	−0.10, −0.02	22	
NPI	2	2,988	−0.23	−01.00, 0.99	77	

cor. = Correlation estimate; GDS = Apathy subscale of the Geriatric Depression Scale; I^2 = Percentage of variability in the correlations that is not caused by sampling error; *k* = Number of studies; MCI = Mild Cognitive Impairment; MET = Metabolic equivalent; NPI = Apathy subscale of the Neuropsychiatric Inventory Questionnaire.

wrist ($k = 2$),[39,92] or pocket ($k = 1$),[52] and one study did not report where the device was worn.[87] Studies based on accelerometer-derived measures used an ActiGraph device (ActiGraph, LLC, Pensacola, FL, USA),[51,79] the Polar M200 (Polar Electro Oy, Kempele, Finland),[92] or the Micro Motionlogger Watch (Ambulatory Monitoring, Ardsley, NY, USA).[39] The pedometers used were the Omron Walking Style Pro 2.0 (Omron Healthcare, Kyoto, Japan),[53] or the Yamasa EX-300 (Yamasa, Choshi, Japan).[52] One study did not specify the pedometer that was used.[87]

To assess physical activity, the studies used the following outcomes: score from a questionnaire (e.g., PASE, PADS, BHPAQ) ($k = 11$),[37,38,40,84,88,91,97–101] MET-min/week (c = 7),[38,53,85,94–96,100] steps per day ($k = 3$),[52,53,87] active time per day or week ($k = 8$),[51,84,86,89,90,92,93,102] counts per minute ($k = 1$),[39] kilocalories per day ($k = 1$).[79] Four studies used multiple physical activity outcomes ($k = 4$).[38,53,84,100]

Association between physical activity and apathy

Among the 28 articles included in the systematic review, 5 reported correlation coefficients of the association between physical activity and apathy. Specifically, 2 articles reported at least 1 Pearson's *r* correlation coefficient[37,89] and 3 other articles reported at least 1 Spearman's ρ.[39,53,92] For 11 studies,[51,52,79,85,87,88,90,91,93,94,98] we computed the Pearson's *r*-value using the exact *p*-value (or *t*-value) and sample size (online Appendix 3). We estimated an approximate *r*-value for 5 studies reporting a relative p-value < 0.001.[95–97,99,101] Through email correspondence with the authors, we obtained 3 additional Pearson's *r*-values[40,78,84] and 1 additional Spearman's ρ-value.[85] Furthermore, we calculated 1 Pearson's *r* value based on publicly available data.[102] In total, we used 22 Pearson's *r*-values from 22 studies[37,39,51,52,78,79,84,85,87–91,93–101] and 7 Spearman's ρ-values from 4 studies[39,53,84,92] in the meta-analysis (Table 1).

The remaining three studies did not report a correlation coefficient, and therefore we did not include them in the meta-analysis. Two of these studies reported a significant negative association between physical activity and apathy based on odds ratios[100] or standardized beta coefficient (β).[38] The third study reported only a relative p-value > 0.05.[86]

Meta-analysis

Main meta-analysis

Our meta-analysis of 22 studies ($N = 12{,}541$) based on Pearson's *r*-values revealed a statistically significant small negative correlation between apathy and physical activity ($r = -0.13$; 95% CI: -0.18, -0.09; $p < 0.0001$; see Table 2 and Figure 2). Further supporting this result,

Study (Year)	Total	Weight	Correlation IV, Random, 95% CI
Ito (2021)[52]	101	3.5%	0.05 (−0.15, 0.24)
Friedmann (2014)[79]	40	1.6%	−0.03 (−0.34, 0.28)
Grool (2014)[101]	4,354	12.2%	−0.05 (−0.08, −0.02)
Henstra (2019)[99]	2,893	11.8%	−0.06 (−0.10, −0.02)
Krell-Roesch (2023)[97]	2,965	11.9%	−0.06 (−0.10, −0.02)
Lemij (2023)[94]	239	6.1%	−0.08 (−0.20, 0.05)
Groeneweg-Koolhoven (2016)[85]	266	6.5%	−0.12 (−0.24, 0.00)
Miura (2014)[91]	32	1.3%	−0.12 (−0.45, 0.24)
Henstra (2018)[98]	243	6.2%	−0.15 (−0.27, −0.02)
Knak (2020)[51]	67	2.5%	−0.17 (−0.39, 0.07)
Henstra (2019)[95]	380	7.6%	−0.17 (−0.27, −0.07)
Henstra (2021)[96]	394	7.7%	−0.17 (−0.26, −0.07)
Rios Romenets (2015)[84]	33	1.3%	−0.18 (−0.49, 0.17)
Ng (2021)[40]	121	4.0%	−0.23 (−0.39, −0.05)
Ringen (2018)[93]	83	3.0%	−0.24 (−0.43, −0.03)
Abrantes (2012)[89]	45	1.8%	−0.25 (−0.51, 0.05)
Talamonti (2022)[102]	41	1.6%	−0.25 (−0.52, 0.06)
Vanner (2008)[37]	43	1.7%	−0.27 (−0.53, 0.03)
Hamre (2021)[88]	101	3.5%	−0.32 (−0.49, −0.13)
Ito (2020)[87]	60	2.3%	−0.32 (−0.53, −0.07)
Sacheli (2018)[90]	17	0.7%	−0.40 (−0.74, 0.10)
Ayari (2023)[78]	23	0.9%	−0.48 (−0.74, −0.08)
Total (95% CI)	12,541	100.0%	−0.13 (−0.18, −0.09)
Prediction interval			(−0.26, 0.00)

Heterogeneity: $\tau^2 = 0.0038$; $\chi^2 = 41.18$, $df = 21$ ($p < 0.01$); $I^2 = 49\%$

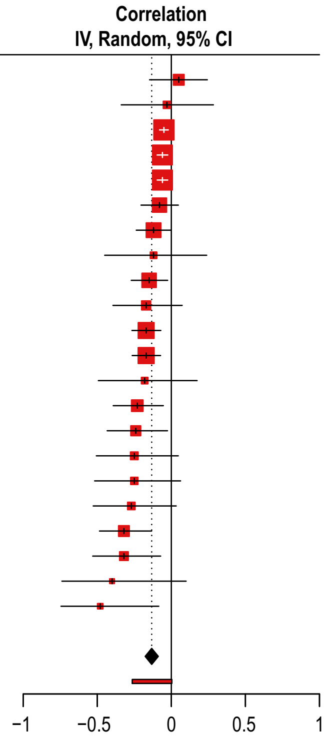

Figure 2 Main meta-analysis. Correlation between apathy and physical activity based on Pearson's *r*-values ($k = 22$, $n = 12{,}541$). IV = inverse variance.

Figure 2 Extended Description

between-study statistical heterogeneity could be considered moderate ($\tau^2 = 0.0038$; 95% CI: 0.0003, 0.0167; $I^2 = 49.0\%$; 95% CI: 16.4, 68.9), and the prediction interval ranged from $r = -0.26$ to 0.00, suggesting that the correlation would be negative for a future study.

Publication bias assessment

The funnel plot showed an asymmetrical pattern (Figure 3a), with more studies on the left of the vertical dashed line representing the average effect size. In addition, if we input the missing studies in the right part of the plot to increase the symmetry, most of these studies would lie in the non-significance region (in white), which suggests that the asymmetry in the funnel plot may be caused by publication bias rather than other potential causes, such as different study procedures and between-study heterogeneity. Egger's regression test confirmed that the data in the funnel plot was asymmetric ($b = -1.44$; 95% CI: −1.97, −0.91; $p = 3.1 \times 10^{-5}$). However, the bias-corrected estimate of the true effect size, calculated using Rücker's limit meta-analysis method, showed that the small correlation reported in the main analysis would remain significant even if such publication bias was present in our data set ($r = -0.08$; 95% CI: −0.14, −0.02; $p = 0.0065$).

We provided 29 correlation values (Pearson's r or Spearman's ρ) to the p-curve analysis (Figure 3b). The observed p-curve included 14 statistically significant results ($p < 0.05$), 13 of which were highly significant ($p < 0.025$). The p-value of the right-skewness test was < 0.001 for both the half curve (curve of p-values ≤ 0.025) and the full curve (curve of p-values < 0.05), confirming that the p-curve was right-skewed and suggesting that the effect of our meta-analysis is true, i.e., that the effect we estimated is not an artifact caused by selective reporting (e.g., p-hacking) in the literature.[106] In addition, the statistical power of the studies that were included in the p-curve analysis was 90% (90% CI: 77, 97), suggesting that approximately 90% of the significant results are expected to be replicable.

Secondary meta-analysis

Results of the secondary meta-analysis based on Spearman's ρ-values ($k = 4$, $n = 543$) were consistent with those based on Pearson's r as they showed a statistically significant moderate to large negative correlation between apathy and physical activity ($r = -0.40$; 95% CI: −0.68, −0.02; $p = 0.043$) (Figure 4). However, we observed substantial to considerable between-study statistical heterogeneity (between-cluster $\tau^2 = 0.09$; 95% CI: 0.01, 0.97;

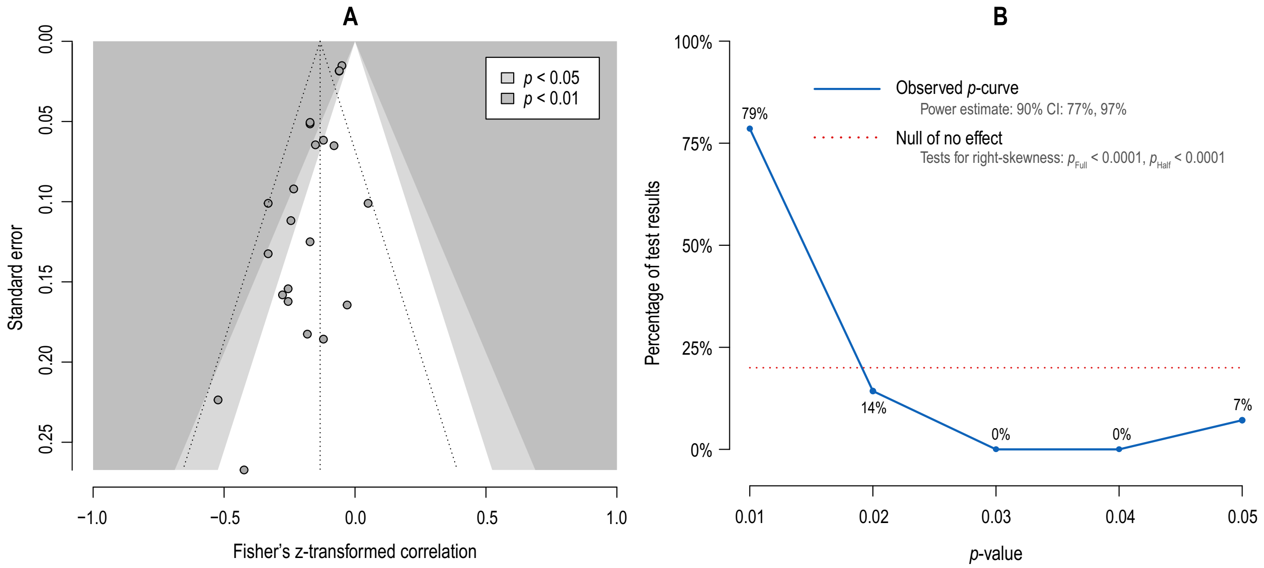

Figure 3 Publication bias assessment: (a) contour-enhanced funnel plot of the main meta-analysis and (b) *p*-curve analysis.
Notes: (a) The vertical dashed line represents the average effect size. The two other dashed lines represent the idealized funnel-shape that studies are expected to follow. When there is no publication bias, the data points in a funnel plot should form a roughly symmetrical, upside-down funnel. Studies in the top part of the plot, which have lower standard errors, are expected to lie closely together, and not far away from the pooled effect size. In the lower part of the plot, studies have higher standard errors, the funnel "opens up," and effect sizes are expected to scatter more heavily to the left and right of the pooled effect. (b) The solid line indicates the distribution of the analyzed *p*-values. The dotted line illustrates a uniform distribution of the *p*-values, indicating the absence of a true effect.

$I^2 = 82.0\%$; 95% CI: 64.1, 91.0), and the prediction interval ranged from $r = -0.87$ to 0.45, indicating that a moderate to large positive correlation cannot be ruled out for future studies.

The sampling error variance on level 1 and the value of I^2 on level 2 (i.e., the amount of heterogeneity variance within studies) were small (12.4% and 3.5×10^{-9}%, respectively). The largest share of heterogeneity variance was from level 3, with between-study heterogeneity making up 87.6% of the total variation in our data. Overall, this indicates that there is considerable between-study heterogeneity, and that little variance results from differences within studies. However, the three-level model showed a better fit than the two-level model with lower Akaike's information criterion (AIC) (3.2 vs. 6.6) and Bayesian information criterion (BIC) (2.6 vs. 6.2), indicating better performance. These lower AIC and BIC are consistent with the significant likelihood ratio test comparing the two models ($\chi^2 = 5.35$; $p = 0.0207$). Therefore, although the three-level model introduces an additional parameter, this added complexity has improved our estimate of the pooled effect.

Subgroup meta-analyses

To test for subgroup differences between health status, we compared studies comprising older adults who were

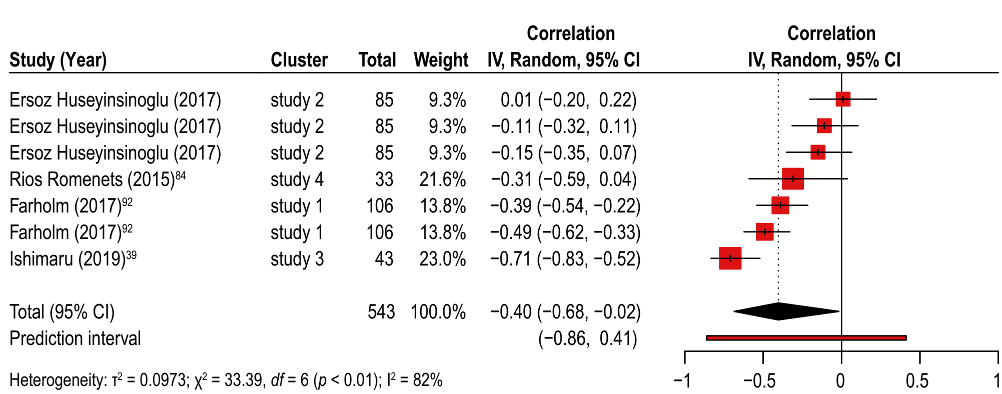

Figure 4 Secondary meta-analysis. Correlation between apathy and physical activity based on Spearman's rho values ($k = 7$, $n = 437$)
IV = inverse variance.

Figure 4 Extended Description

healthy, depressed, fallers, or had mild cognitive impairment ($k = 10$), people with Parkinson's disease ($k = 5$), and stroke survivors ($k = 3$). We found statistical difference between these studies ($p < 0.0001$) (Table 2; online Figure S1). The relationship between apathy and physical activity was statistically significant in studies that included older adults ($r = -0.10$; 95% CI: −0.15, −0.05) or patients with Parkinson's disease ($r = -0.22$; 95% CI: −0.31, −0.14), but not in studies that included stroke survivors ($r = -0.20$; 95% CI: −0.64, −0.34). However, statistical power was lacking in the latter ($k = 3$) and other health status ($k = 1$).

To test for subgroup differences between physical activity outcomes, we compared studies using a score from a questionnaire ($k = 7$), MET-min per week ($k = 6$), active time per day or week ($k = 5$), and steps per day ($k = 2$) (Table 2; online Figure S2). We found statistical difference between these studies ($p < 0.0001$). The relationship between apathy and physical activity was statistically significant in studies using a score ($r = -0.14$; 95% CI: −0.23, −0.04), MET-min/week ($r = -0.15$; 95% CI: −0.22, −0.08), and active time ($r = -0.22$; 95% CI: −0.30, −0.14), but not in studies that used the number of steps per day ($r = -0.13$; 95% CI: −0.99, 0.98). However, statistical power was lacking in the latter ($k = 2$) and other physical activity outcomes ($k = 1$).

To test for subgroup differences between apathy measures, we compared studies using the Apathy Scale ($k = 11$), the Apathy Evaluation Scale ($k = 5$), the apathy subscale of the Geriatric Depression Scale ($k = 4$), and the apathy subscale of the Neuropsychiatric Inventory Questionnaire ($k = 2$) (Table 2; online Figure S3). The relationship between apathy and physical activity was statistically significant in studies using the Apathy Scale ($r = -0.15$; 95% CI: −0.20, −0.10), Apathy Evaluation Scale ($r = -0.23$; 95% CI: −0.35, −0.11), and Geriatric Depression Scale ($r = -0.06$; 95% CI: −0.10, −0.02), but not in studies that used the Neuropsychiatric Inventory Questionnaire ($r = -0.23$; 95% CI: −1.00, 0.99). However, statistical power was lacking in the latter apathy measure ($k = 2$).

Meta-regressions

Age statistically influenced the correlation values of the meta-analysis studies ($k = 21$; $p = 0.003$) (online Figure S4a), with older samples being associated with more negative relationships between apathy and physical activity. Conversely, the proportion of women did not statistically influence the meta-analysis studies' correlation values ($k = 21$; $p = 0.346$) (online Figure S4b).

Sensitivity analysis

The meta-regression by quality score based on the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies[61] ($k = 22$) showed that a study's quality did not influence correlation values ($p = 0.986$) (online Figure S4c).

DISCUSSION

Clinical implications

As hypothesized, the main meta-analysis based on Pearson's r-values showed a small negative correlation between apathy and physical activity. The secondary analysis based on Spearman's ρ-values showed a moderate to large negative correlation, further supporting the results. While larger effect sizes may result in more noticeable clinical differences at the individual level and in the short term, smaller effect sizes may also have important clinical implications, especially when considered in the context of population health, prevention strategies, and long-term outcomes. Given the important contribution of physical activity to the primary, secondary, and tertiary prevention of many diseases including cardiovascular disease,[107,108] stroke,[49,109] depression,[110,111] obesity,[112] dementia,[113] osteoarthritis,[114] and cancer,[115] the small effect size we report in the main meta-analysis based on Pearson's r-values may translate into meaningful clinical improvements in patient outcomes.

Health professionals have an important role to play in preventing and reducing the detrimental effects of apathy on physical activity. Studies have shown that non-pharmacological interventions such as multisensory stimulation, music therapy, cognitive stimulation, and pet therapy are effective in decreasing apathy.[116] Physical therapists can contribute through exercise therapy as intervention studies have shown that exercise can reduce apathy,[117,118] opening the possibility for a virtuous circle, as this reduced apathy can then support physical activity engagement.

In patients with apathy, the exercise intervention should take into consideration the reduced motivation, as this will affect the patient's ability to adhere to the prescribed programme.[3] Since the perceived cost of physical activity is higher in this population, the therapist needs to find ways to increase the rewards associated with the intervention. These rewards can be intrinsic (e.g., fun activity) or extrinsic (e.g., validation of the progression checks set by the therapist).

Underlying mechanisms and health status

The mechanisms underlying the association between apathy and physical activity remain poorly understood and overlooked. One exception is a recent study showing that weaker intention to be physically active mediated the association between higher levels of behavioural apathy and lower habitual levels of moderate-to-vigorous physical activity.[119] In addition, explicit attitudes mediated the effect of behavioural apathy on intentions to be physically active. These findings indicate the involvement of controlled motivational processes, allowing for potential interventions to reduce the detrimental effects of apathy on physical activity.

Our meta-analysis observed the largest significant effect size in patients with Parkinson's disease, which can be used as a model to better understand the mechanisms underlying the association between apathy and physical activity. This association is consistent with the decision theory of goal-directed behaviour.[120] According to this theory, people contrast costs and benefits when considering whether to engage in physical activity. Engagement occurs when the net value of this contrast is beneficial. According to studies of patients with Parkinson's disease, apathy results from dopamine depletion in the brain.[121–125] When dopaminergic medications address this depletion, studies have shown that patients are more willing to squeeze a handgrip to earn a reward than to decline,[126] and they exert more force to earn a reward.[127,128] Taken together, these results suggest that in patients with Parkinson's disease, apathy may be associated with dopaminergic deficits that could increase the perceived cost of physical effort, thereby decreasing the willingness to engage in physical activity.

In addition to patients with Parkinson's disease, our subgroup meta-analyses suggest that the negative relationship between apathy and physical activity is in older adults who were healthy, depressed, fallers, or had mild cognitive impairment. The meta-regression further supports this result, showing that older ages were associated with more negative relationships between apathy and physical activity. The higher metabolic energy associated with a given physical activity in older adults compared to young adults could explain this effect of aging.[129–131] This decreased efficiency may increase the cost for engaging in physical activity in a non-linear manner across the years, amplifying the impact of apathy on the engagement in physical activity. Moreover, studies suggest that apathy increases with age,[55] which would further contribute to amplifying the impact of this decreased efficiency on physical activity.

Although there was no clear evidence of an association between apathy and physical activity in other health conditions, we cannot rule out such an association, as the lack of statistical significance could result from a lack of statistical power in these health conditions (e.g., stroke) or by the impossibility of comparing them with other health conditions in the subgroup meta-analysis, as they were only examined in a single study (e.g., cancer). Contrary to previous studies,[55,56,132] our results showed no evidence of an effect of gender.

Measures of physical activity and apathy

Both self-reported (e.g., MET-minutes per week) and device-based outcomes (e.g., active time per day or per week) of physical activity were negatively associated with apathy, suggesting that both these approaches can capture this relationship. Apathy was not associated with the number of steps per day, but this analysis may be underpowered because it included only two studies with a total of 161 participants, some of whom may have been included in these two studies from the same group with similar methods and partly overlapping recruitment periods.[52,87]

The three most used measures of apathy (Apathy Scale, Apathy Evaluation Scale, Apathy Subscale of the Geriatric Depression Scale) were all associated with physical activity, further supporting the robustness of this association. Only one measure of apathy showed no evidence of an association with physical activity, but this result was based on only two studies, which both showed a significant negative association.

Several limitations impact the results of this systematic review and meta-analysis. (1) We only included articles published in English. Inclusion of articles published in other languages may have influenced the results. (2) Due to the correlational nature of the meta-analyzed results, we cannot conclude a causal relationship between apathy and physical activity, nor can we exclude the possibility that this relationship is indirect, i.e., mediated by other factors. (3) We did not preregister the meta-analysis because the author with this expertise (IML) joined only after we conducted the systematic review. However, since the preregistered systematic review defines the studies included in the meta-analysis and since the *meta* R package[63] provides very few degrees of freedom, there was little room for bias in the main and secondary meta-analyses. This reasoning also applies to the subgroup analyses because the studies included in the systematic review imposed the health conditions, types of physical activity measures, measurement instruments, and outcomes, as well as the apathy measurement instruments. (4) A small number of the 43 authors we contacted (3, 7%) shared their estimates (2, 5%) or raw data (1, 2%) with us, which is less than reported in previous literature.[133] Including these estimates may have influenced our results.

CONCLUSION

Our results suggest that higher levels of apathy are associated with lower levels of physical activity and that this negative association is stronger with age. As such, apathy may be a limiting factor to exercise therapy, which is within the scope of practice of physiotherapists,[134] and may have prognostic implications in patients whose condition requires physical activity. Accordingly, physiotherapists should screen for apathy when a patient has difficulty engaging in physical activity, especially patients with Parkinson's disease and older adults, and develop strategies to increase the intrinsic and extrinsic motivation associated with physical activity in those who experience apathy.

KEY MESSAGES

What is already known on this topic

Apathy is a behavioural disorder characterized by a state of primary motivational impairment. Apathy occurs across a wide range of health conditions, including dementia, schizophrenia, Parkinson's disease, and stroke. Physical activity contributes to the primary, secondary, and tertiary prevention of cardiovascular disease, stroke, depression, obesity, dementia, osteoarthritis, and cancer.

What this study adds

Results show a negative correlation between apathy and physical activity. We observed the strongest association in patients with Parkinson's disease. The older the participants, the stronger the association between apathy and physical activity.

Authors' Contributions: Conceptualization: MP Boisgontier, A Farajzadeh; Data Curation: MP Boisgontier, A Farajzadeh; Funding Acquisition: MP Boisgontier; Formal Analysis: IM Lahart, MP Boisgontier, A Farajzadeh; Supervision: MP Boisgontier, M Bilodeau; Visualization: IM Lahart, MP Boisgontier; Project Administration: MP Boisgontier; Investigation: A Farajzadeh, A Hébert, MP Boisgontier; Methodology: MP Boisgontier, IM Lahart, A Farajzadeh; Writing – Original Draft: MP Boisgontier, A Farajzadeh; Writing – Review & Editing: MP Boisgontier, A Farajzadeh, IM Lahart, M Bilodeau.

Ethics Approval and Informed Consent: N/A

Registry and the Registration No. of the Study/Trial: N/A

Data Accessibility: In line with good research practices,[135] the dataset as well as R and R Markdown scripts are freely available in Zenodo (https://doi.org/10.5281/zenodo.10929857).

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FIGURE DESCRIPTIONS

Figure 1 Extended Description

- Identification of studies via databases and registers
  - Records identified ($N = 6{,}950$) from CINAHL ($n = 463$), Embase ($n = 1{,}580$), MEDLINE ($n = 1{,}625$), PsycInfo ($n = 509$), SPORTDiscus ($n = 638$), Web of Science ($n = 2{,}135$)
    - Records removed *before screening*: duplicates ($n = 2{,}025$)
  - Records screened ($n = 4{,}925$)
    - Records excluded: not original data ($n = 1{,}321$) and unrelated to apathy or physical activity ($n = 3{,}441$)
  - Reports sought for retrieval ($n = 163$)
    - Reports not retrieved ($n = 0$)
  - Reports assessed for eligibility ($n = 163$)
    - Reports excluded: no physical activity measure ($n = 60$), no apathy measure ($n = 10$), no physical activity and apathy ($n = 8$), and association not tested ($n = 40$)
  - Studies included in review ($n = 28$)
- Identification of studies via other methods
  - Records identified from citation searching ($n = 18$)
    - Records removed *before screening*: duplicates ($n = 2{,}205$)
  - Records screened ($n = 14$)
    - Records excluded: not original data ($n = 2$) and unrelated to apathy or physical activity ($n = 3$)
  - Reports sought for retrieval ($n = 9$)
    - Reports not retrieved ($n = 0$)
  - Reports assessed for eligibility ($n = 9$)
    - Reports excluded: no physical activity measure ($n = 5$) and no apathy measure ($n = 1$)

Back to Figure 1.

Figure 2 Extended Description

Data:

Study (Year)	Total	Weight	Correlation IV, random (95% CI)
Ito (2021)[52]	101	3.5%	0.05 (−0.15, 0.24)
Friedmann (2014)[79]	40	1.6%	−0.03 (−0.34, 0.28)
Grool (2014)[101]	4,354	12.2%	−0.05 (−0.08, −0.02)
Henstra (2019)[99]	2,893	11.8%	−0.06 (−0.10, −0.02)
Krell-Roesch (2023)[97]	2,965	11.9%	−0.06 (−0.10, −0.02)
Lemij (2023)[94]	239	6.1%	−0.08 (−0.20, 0.05)
Groeneweg-Koolhoven (2016)[85]	266	6.5%	−0.12 (−0.24, 0.00)
Miura (2014)[91]	32	1.3%	−0.12 (−0.45, 0.24)
Henstra (2018)[98]	243	6.2%	−0.15 (−0.27, −0.02)
Knak (2020)[51]	67	2.5%	−0.17 (−0.39, 0.07)
Henstra (2019)[95]	380	7.6%	−0.17 (−0.27, −0.07)
Henstra (2022)[96]	394	7.7%	−0.17 (−0.26, −0.07)
Rios Romenets (2015)[84]	33	1.3%	−0.18 (−0.49, 0.17)
Ng (2021)[40]	121	4.0%	−0.23 (−0.39, −0.05)
Ringen (2018)[93]	83	3.0%	−0.24 (−0.43, −0.03)
Abrantes (2012)[89]	45	1.8%	−0.25 (−0.51, 0.05)
Talamonti (2022)[102]	41	1.6%	−0.25 (−0.52, 0.05)
Vanner (2008)[37]	43	1.7%	−0.27 (−0.53, 0.03)
Hamre (2021)[88]	101	3.5%	−0.32 (−0.49, −0.13)
Ito (2020)[87]	60	2.3%	−0.32 (−0.53, −0.07)
Sacheli (2018)[90]	17	0.7%	−0.40 (−0.74, 0.10)
Ayari (2023)[78]	23	0.9%	−0.48 (−0.74, −0.08)
Total (95% CI)	12,541	100.0%	−0.13 (−0.18, −0.09)
Prediction interval			(−0.26, 0.00)

Heterogeneity: $\tau^2 = 0.0038$; $\chi^2 = 41.18$, $df = 21$ ($p < 0.01$); $I^2 = 49\%$.

Back to Figure 2.

Figure 4 Extended Description

Data:

Study (Year)	Cluster	Total	Weight	Correlation IV, random (95% CI)
Ersöz Hüseyinsinoğlu (2017)[53]	study 1	85	9.3%	0.01 (−0.20, 0.22)
Ersöz Hüseyinsinoğlu (2017)[53]	study 1	85	9.3%	−0.11 (−0.32, 0.11)
Ersöz Hüseyinsinoğlu (2017)[53]	study 1	85	9.3%	−0.15 (−0.35, 0.07)
Rios Romenets (2015)[84]	study 2	33	21.6%	−0.31 (−0.59, 0.04)
Farholm (2017)[92]	study 3	106	13.8%	−0.39 (−0.54, 0.22)
Farholm (2017)[92]	study 3	106	13.8%	−0.49 (−0.62, −0.33)
Ishimaru (2019)[39]	study 4	43	23.0%	−0.71 (−0.83, −0.52)
Total (95% CI)		543	100.0%	−0.40 (−0.68, −0.02)
Prediction interval				(−0.87, 0.45)

Heterogeneity: $\tau^2 = 0.0973$; $\chi^2 = 33.39$, $df = 6$ ($p < 0.01$); $I^2 = 82\%$.

Back to Figure 4.