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

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Abstract

Objective. Physical activity is known to reduce the risk of disability, disease, and mortality. However, in some patients, an excessive, irrational, and debilitating fear of movement (i.e., kinesiophobia) is thought to induce avoidance behaviors, contributing to decreased engagement in physical activity. The aim of this study was to examine whether kinesiophobia is negatively associated with physical activity and what factors influence this relationship.

Methods. Three databases were searched for articles including both a measure of kinesiophobia and physical activity. Two reviewers screened articles for inclusion, assessed risk of bias, and extracted data from each study. Pearson product-moment correlations were pooled from eligible studies using the generic inverse pooling and random effects method to examine the relationship between kinesiophobia and physical activity.

Results. Forty-nine articles were included in the systematic review and 41 studies (n = 4,848) in the meta-analysis. Results showed a moderate negative correlation between kinesiophobia and physical activity ($r = -0.31$; 95% CI: -0.42 to -0.20; $I^2 = 1.8\%$; $p < 0.0001$). Subgroup meta-analyses revealed that the correlation was statistically significant only in patients with a cardiovascular or arthritis condition and in studies using a self-reported measure of physical activity. There was no evidence of an effect of age, gender, or pain.

Conclusions. Higher levels of kinesiophobia were moderately associated with lower levels of physical activity. However, between-study heterogeneity was considerable, and results showed no evidence of this association when physical activity was assessed with accelerometers or pedometers. Additional studies using device-based measures of physical activity are required to confirm these results and to understand the factors and mechanisms influencing this potential relationship.

Impact. Our results suggest that kinesiophobia could be considered as a limiting factor when developing physical activity promotion strategies for inactive patients.

Seven decades ago, the seminal work of Morris et al. (1953)[1] showed that conductors on London double-decker buses, who were responsible for checking tickets, assisting passengers with luggage, and supervising the loading and unloading of passengers, had a lower incidence and less severe coronary heart disease than bus drivers. Since then, the scientific literature demonstrating the health benefits of physical activity has grown exponentially and expanded to include multiple health conditions[2]. These benefits include reduced risk of disability, disease, and mortality[2,3]. Specifically, higher levels of physical activity have been shown to contribute to a reduced risk of cardiovascular disease[4], obesity[5], depression[6], hypertension[7], cancer[8], and dementia[9]. Yet, one in four adults worldwide does not meet the recommendations for physical activity[10].

Several factors may explain physical inactivity[11]. Environmental, interpersonal, and intrapersonal factors[12]. Environmental factors include lack of access, weather conditions, and safety concerns[13]. Interpersonal factors include family responsibilities, lack of support, and lack of a gym partner[14]. Intrapersonal factors include gender[15], age[16], cognitive function[17,18], and socioeconomic circumstances[19]. One intrapersonal factor of interest in patients is kinesiophobia[20], which can be defined as an excessive, irrational, and debilitating fear of movement and activity resulting from a sense of vulnerability to pain, injury, or a medical condition. Kinesiophobia is typically measured using self-administered questionnaires, such as the Tampa Scale of Kinesiophobia (TSK)[21,22], which assesses an individual's belief that physical activity can lead to injury or pain and that the severity of their medical condition is underestimated.

The relationship between kinesiophobia and physical activity can be explained within the framework of dual models, which propose that physical activity behavior is governed by two main processes: Controlled and automatic processes[23–26]. Controlled processes rely on higher brain functions, are deliberative, require cognitive resources, and are developed through conscious thought. Automatic processes, on the other hand, rely on learned associations, are unintentional, require fewer cognitive resources, and do not require conscious thought. Regarding automatic processes, these models propose that the perception of a cue related to physical activity automatically activates the concept of physical activity as well as the unpleasant (or pleasant) affective memories associated with this concept[25,26]. This activation leads to an impulse that favors the tendency to avoid (or approach) physical activity[27]. Thus, negative affective associations are likely to hinder physical activity. Accordingly, an aversive fear of pain, injury, or aggravation of a medical condition that has been associated with the concept of movement may result in the development of automatic avoidance behaviors that contribute to the maintenance and exacerbation of this fear, and ultimately lead to a phobic state (i.e., kinesiophobia) that diminishes the ability to engage in regular physical activity.

The main objective of this study was to systematically review and meta-analyze the direct relationship between kinesiophobia and physical activity. We hypothesized that levels of kinesiophobia would be negatively associated with levels of physical activity. In addition, we examined whether this association was influenced by kinesiophobia measures, physical activity measures (i.e., accelerometers, pedometers, questionnaires), physical activity outcome (e.g., total physical activity, moderate or vigorous physical activity, steps per day), health status, age, gender, or pain.

Methods

Search Strategy

This review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[28]. Potential studies were identified by searching the MEDLINE (via PubMed), PsychInfo, and CINAHL databases. In October and November 2022, two reviewers (MG and AF) searched for all available records using the following combination of keywords in the title or abstract of the article: "kinesiophobia" and "physical activity". Specifically, in PubMed, the search was "physical activity" (MeSH terms) AND "kinesiophobia" (All Fields)". In PsychInfo and CINAHL, the search was "kinesiophobia"

AND "physical activity" in all fields. To reduce literature bias[29,30], this systematic review was pre-registered in PROSPERO[31].

Eligibility Criteria and Study Selection

Inclusion Criteria

To be included in this systematic review, articles had to be published in a peer-reviewed journal, be written in English, report original data collected from human participants, include at least one self-reported measure of kinesiophobia and one measure of physical activity, and formally test the association between these two variables. The physical activity measure could be a self-reported measure of the level of physical activity or the use of an accelerometer while participants are engaged in their normal daily activities.

Exclusion Criteria

Studies were excluded if they were published as a book chapter, study protocol, conference abstract, or were 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

Article screening was performed in Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia; www.covidence.org), a web-based collaborative software platform that streamlines the production of systematic reviews. After removing duplicates, titles and abstracts were independently reviewed by two reviewers (MG, AF) according to the inclusion and exclusion criteria using a systematic 5-step process. If there was any doubt at any step, the full text was further reviewed. Step 1: Articles not written in English were excluded. Step 2: Articles that did not report original empirical data were excluded (e.g., reviews, meta-analyses, commentaries, technical reports, case studies). Step 3: Articles that did not involve human participants were excluded. Step 4: Articles that did not assess both kinesiophobia and physical activity were excluded. Step 5: Articles that did not formally test the association between kinesiophobia and physical activity were excluded. In addition, we performed reference screening and forward citation tracking on the articles remaining after step 5. Any disagreements between the two reviewers were resolved by consensus among four reviewers (MG, AF, MB, MPB).

Data Extraction

Data extracted from selected articles included first author's name, article title, publication year, digital object identifier (DOI), number of participants, number of men and women, age range, mean age, mean weight, mean height, mean body mass index, health status, mean pain intensity, type of kinesiophobia measure, level of kinesiophobia, type of physical activity measure, type of physical activity outcome, level of physical activity, as well as statistical estimates and significance of the association between kinesiophobia and physical activity.

Bias Assessment

The risk of bias of the studies included in the systematic review was estimated using the critical appraisal tool for assessing the quality of cross-sectional studies (AXIS)[32]. AXIS is a 20-item checklist designed to assess the introduction, methods, results, discussion, conflict of interest, and ethical approval or consent of the included studies.

Meta-Analysis

In our meta-analysis, we pooled Pearson product-moment correlations from eligible studies to examine the relationship between kinesiophobia and physical activity. When a study measured physical activity with both a questionnaire and accelerometers, the correlation included in the analysis was that of the most reliable outcome, i.e., the accelerometer-based outcome. Correlations were pooled using the generic inverse pooling method via the 'metacor' function in the R 'meta' package[33]. This function automatically performs a necessary Fisher's z-transformation on the original, untransformed correlations prior to pooling. The 'metacor' function also reconverts the pooled association back to its original form for ease of interpretation.

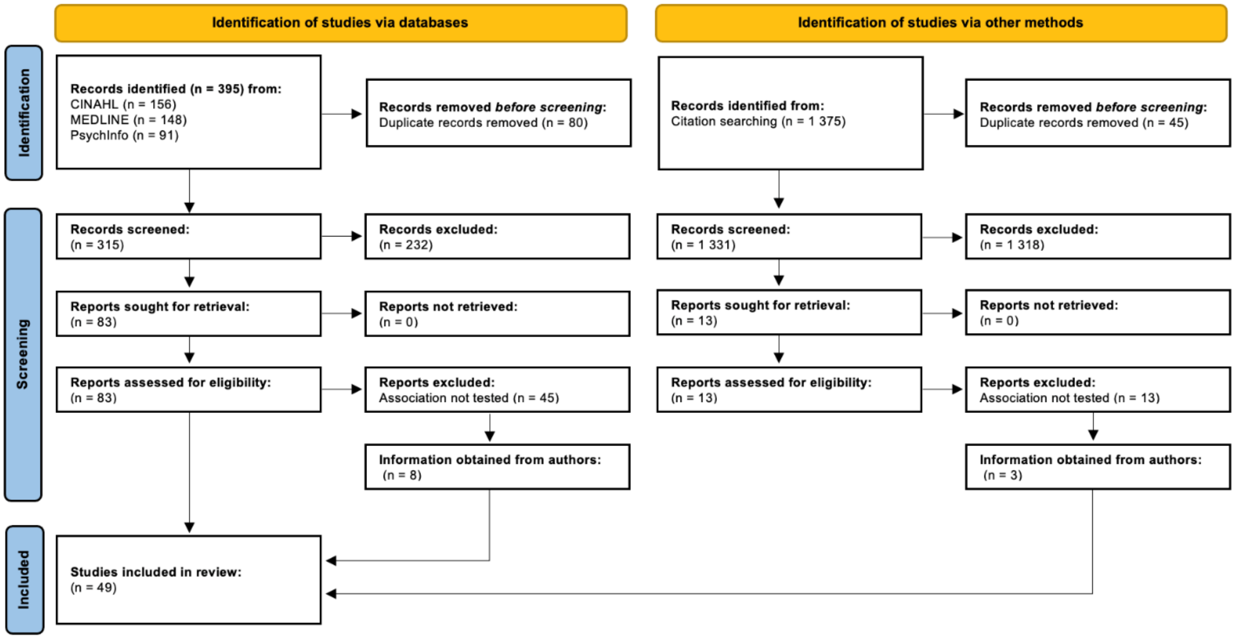

Figure 1. PRISMA 2020 flow diagram

We anticipated considerable between-study heterogeneity, and therefore used a random-effects model to pool correlations. The restricted maximum likelihood (RML) estimator[34] was used to calculate the heterogeneity variance Tau^2. In addition to Tau^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[35]. The I^2 statistic was interpreted 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[36] 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. The pooled correlation was interpreted using Cohen's conventions[37] : $r \approx -0.10$, small negative correlation; $r \approx -0.30$, moderate negative correlation; $r \approx -0.50$, large negative correlation. Egger's regression test of funnel plot asymmetry[38] and a p-curve analysis[39] were conducted to assess potential publication bias in our meta-analysis. The Rücker's limit meta-analysis method[40], which explicitly includes the heterogeneity variance in the model, was used to compute bias-corrected estimate of the true effect size.

We conducted subgroup analyses to examine the differences in correlations between studies including participants with different health conditions and using different types of physical activity measures (i.e., device-based vs. self-reported), physical activity measurement instruments (i.e., type of questionnaires, type of devices), physical activity outcomes, and kinesiophobia measures. In addition, we used meta-regressions to examine if the average age of participants or the proportion of women in a study predicted the reported correlation between kinesiophobia and physical activity.

A secondary meta-analysis was conducted using the same approach, but based on Spearman's rho values, to further test the relationship between kinesiophobia and device-based physical activity.

A sensitivity analysis was conducted to examine whether the quality of the studies (AXIS score) affected the results.

All analyses were performed in RStudio integrated development environment (IDE) (2023.06.1+524, “Mountain Hydrangea” release) for R software environment[41] using the ‘meta’, ‘metafor’, and ‘metasens’ R packages[33,40,42,43].

Results

Literature Search

The primary search identified 395 potentially relevant articles from the three databases (Figure 1), including 80 duplicates. Of the 315 articles screened, disagreement occurred in 25 cases (7.9%), all of which were resolved by consensus. All articles remained after step 1 as they were all written in English. Ninety-six articles were excluded in step 2 because they did not report original data. No articles were excluded in step 3 because they all involved human participants. One hundred and thirty-six articles were excluded in step 4 because they did not assess kinesiophobia (k =3) or physical activity (k = 133). Forty-five articles were excluded at step 5 because they did not formally test the association between the kinesiophobia and physical activity. The corresponding authors of these latter articles were contacted by email to request the Pearson correlation value of this association and the sample size used to calculate it or the raw data for the physical activity and kinesiophobia measures. Fifteen authors replied to our email: 3 authors provided their datasets[44–46], 5 authors provided the Pearson’s correlation value[47–51], 4 authors replied that they would contact their co-authors but did not get back to us. Based on reference screening and forward citation tracking, the authors identified 13 studies that assessed both physical activity and kinesiophobia, but none provided an estimate of their relationship. The corresponding authors of these 13 studies were asked by email to share this estimate or their data. Three of them responded and provided the Pearson’s correlation value[52–54]. The remaining 10 authors did not respond to our email. In total, data from 49 articles were included in the systematic review. AXIS scores ranged from 14 to 18 out of 20, with a mean of 16.9 ± 0.6 (Table 1).

Descriptive Results

Participants

The 49 articles identified by the systematic review included a total of 6,084 participants aged 11 to 85 years, including 2,655 women, 1,967 men, and 1,462 participants whose gender and sex was not reported. The studies investigated populations with pain (k = 20[44,46,49,55–71]), cardiovascular (k = 6[52,53,72–75], surgery (k = 6[45,75–79]), arthritis (k = 6[51,80–84]), neurological (k = 2[85,86]), pulmonary (k = 2[87,88]), and cancer (k = 1[50]) conditions, as well as healthy adults (k = 6 [47,48,54,89–91] (Table 1).

Kinesiophobia

In 44 of the 49 studies, kinesiophobia was assessed using the 17-item TSK (k = 30)[44,47–49,51,54–58,61–65,68,70,77,79–81,83–88,90,92], shorter versions of the TSK [TSK-11[93], k = 8[45,60,66,67,71,75,78,91]; TSK-14, k = 1[50]; TSK-13[94], k = 2[59,76]], or its adaptation for patients with coronary artery disease [TSK-Heart[95], k = 2[52,72]]. The TSK is a questionnaire that assesses the belief that movements can lead to (re)injury, pain, or aggravation of an underlying and serious medical condition[22]. Each item is rated on a Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). On the TSK-17, a score of 37 is used to distinguish between low (≤ 37) and high (> 37) levels of kinesiophobia[21]. On the TSK-13, scores inferior to 23 are considered sub-clinical[96]. The other measures that were used are the Kinesiophobia Causes Scale[97] (KCS; k = 2[54,89]), the Fear of Activities in Situations scale[74] (FActS; k = 1[74]), the Brief Fear of Movement Scale for Osteoarthritis[98] (BFMSO; k = 1[51]), and the Fear-Avoidance Belief Questionnaire[99] (FABQ; k = 1[53]).

Forty-three studies reported mean levels of kinesiophobia (Table 1). The studies based on the TSK-17 or TSK-Heart (mean range: 17 to 68) reporting the highest levels of kinesiophobia were those involving participants with a cardiovascular condition (41.4 to 49.7), followed by studies testing participants with arthritis (31.8 to 45.0), chronic pain (30.5 to 44.4), or a pulmonary condition (39.6 to 42). Levels of kinesiophobia were lower in parti-

Study (Year)	N (# women)	Mean age (SD or range)	Health status	Mean kinesiophobia (SD or range; measure)	Mean physical activity (SD or range; measure)	Level of pain (measure)	Corr.	p-value	AXIS score
Alschuler (2011)	20 (9)	46.1 (9.35)	Chronic low back pain	30.55 (TSK-17)	228 counts/min (wrist accelero.)	4.87 (NRS)	n.a.	0.03	18
Altuğ (2016)	112 (73)	45.0 (14.6)	Chronic low back pain	44.30 (TSK-17)	5495 MET-min/week (IPAQ)	3.45 (VAS)	r = -0.096	0.313	16
Assadourian (2020)	147 (88)	49 (12)	Chronic low back pain	n.a. (TSK-17)	n.a. (diary; < vs. ≥ 1h/week)	6.7 (NRS)	r = -0.022†	0.813†	18
Atici (2022)	254 (171)	n.a. (>65)	Older adults	54.55 (KCS)	182.8 (PASE)	n.a.	ρ = -0.345	<0.001	16
Aydemir (2022)	37 (25)	58.8 (8.6)	Knee osteoarthritis	40.3 (TSK-17)	4.8 (UCLA)	52.0 (KOOS-P)	r = -0.773	<0.05	17
Aykut Selcuk (2020)	67 (67)	60.6 (8.0)	Knee osteoarthritis	44.8 (TSK-17)	n.a. (IPAQ; low vs. moderate vs. high)	4.6 (VAS)	r = -0.247	0.019	17
	29 (0)	61.6 (8.1)	Knee osteoarthritis	42.0 (TSK-17)	n.a. (IPAQ; low vs. moderate vs. high)	2.9 (VAS)	r = -0.309	0.116	
Baday-Keskin (2022)	88 (67)	52 (n.a.)	Rheumatoid arthritis	45 (TSK-17)	594 MET-min/week (IPAQ)	4.8 (VAS)	r = -0.12	>0.05	17
	93 (67)	45 (n.a.)	Healthy adults	39 (TSK-17)	971 MET-min/week (IPAQ)	n.a.	n.a.		
Baez (2020)	40 (24)	24.3 (4.1)	Surgery (ACLR)	18.2 (TSK-11)	8 657 steps/day (hip pedo.)	81.5 (KOOS-P)	r = 0.181†	0.265†	18
					7.7 (TAS)		n.a.	n.a.	
Bahar Özdemir (2021)	101 (59)	33.9 (6.0)	Healthy	36.4 (5.8; TSK-17)	756 MET-min/week (1090; IPAQ)	3.1 (3.3; NRS)	r = -0.007†	0.944†	18
Baykal Şahin (2021)	98 (35)	58.1 (10.4)	Coronary artery disease	41.4 (6.2; TSK-17)	839 MET-min/week (1212; IPAQ)	60.1 (27.2; SF-36)	r = -0.315	0.002	17
Bernard (2015)	121 (121)	65.5 (57-75)	Post-menopausal women	36 (TSK-17)	n.a. (PAQE)	n.a.	r = -0.05†	0.55†	18
Bossenbroek (2009)	15 (10)	53 (6.3)	Pulmonary (COPD)	42 (TSK-17)	1407 steps/day (pedo.)	n.a.	n.a.	n.a.	17
					1349 MET-min/week (SQUASH)				
	47 (29)	55 (5.5)	Lung transplant	30 (TSK-17)	6642 steps/day (pedo.)				
					5434 MET-min/week (SQUASH)				
Carvalho (2017)	119 (82)	39.1 (11.2)	Chronic low back pain	41 (TSK-17)	6844 steps/day (hip accelero.)	6.7 (NRS)	ρ = -0.15	>0.05	17
					296 counts/min (hip accelero.)		r = -0.02	>0.05	
					22 min MVPA/day (hip accelero.)		ρ = -0.13	>0.05	
					333 min LPA/day (hip accelero.)		r = 0.09	>0.05	
					6.7 (BHPAQ)		r = -0.18	<0.05	
Coronado (2021)	248 (126)	62.2 (11.9)	Surgery (laminectomy)	28.4 (TSK-13)	427 counts/min (hip accelerometer)	3.1 (NRS)	r = -0.05	>0.05	16
Corrigan (2018)	53 (18)	54.8 (34-65)	Achilles tendinopathy	35.4 (TSK-17)	n.a. (SGPALS)	n.a.	d = 0.027	0.969	16
Dąbek (2020)	130 (n.a)	n.a.	Coronary disease	44.3 (TSK-Heart)	1545 MET-min/week (IPAQ)	n.a.	r = -0.523	<0.001	17
	119 (n.a)		Hypertension	44.4 (TSK-Heart)	1509 MET-min/week (IPAQ)		r = -0.410	<0.001	
	27 (n.a)		Heart valve defect	44.4 (TSK-Heart)	1308 MET-min/week (IPAQ)		r = -0.201	>0.05	
	72 (n.a)		Myocardial infarction	46.7 (TSK-Heart)	1369 MET-min/week (IPAQ)		r = -0.428	<0.001	
	86 (n.a)		Rhythm disorder	43.3 (TSK-Heart)	1660 MET-min/week (IPAQ)		r = -0.563	<0.001	
	18 (n.a)		Stroke	49.7 (TSK-Heart)	1135 MET-min/week (IPAQ)		r = -0.868	<0.001	
	15 (n.a)		Other CVD	44.2 (TSK-Heart)	2207 MET-min/week (IPAQ)		r = -0.663	0.01	
Demirbüken (2016)	99 (65)	43.5 (12.8)	Chronic neck pain	41.82 (TSK-17)	3749 MET-min/week (IPAQ)	6.47 (VAS)	r = -0.153	n.a.	17
Donnarumma (2017)	51 (12)	61.9 (13.9)	Surgery (laminectomy)	n.a. (TSK-17)	n.a. (IPAQ)	3.5 (GRS)	n.a.	0.01	16
Elfving (2007)	64 (39)	47 (19-64)	Chronic low back pain	n.a. (TSK-13)	n.a. (SGPALS)	n.a.	n.a.	0.010	17
González de La Flor (2022)	42 (32)	36.7 (13.2)	Chronic headache	9 (TSK-11)	n.a. (IPAQ)	7.14 (NRS)	ρ = 0.204	n.a.	17
Helmus (2012)	53 (37)	39.9 (11.3)	Chronic MSK pain	35.4 (TSK-17)	138 counts/min (hip accelero.)	5.8 (VAS)	r = -0.05	0.75	17
Huijnen (2010)	111 (n.a.)	44.1 (10.3)	Subacute low back pain	36.0 (TSK-17)	n.a. (trunk accelero.)	n.a. (NRS)	n.a.	>0.05	17
Kilinç (2019)	200 (120)	53.2 (6.0)	Knee osteoarthritis	31.8. (TSK-17)	1947 MET-min/week (IPAQ)	24.1 (OKS)	r = -0.693	<0.001	17
Knapik (2019)	135 (59)	71.9 (4.8)	Coronary artery disease	43.02 (TSK-Heart)	2.60 (ad-hoc questionnaire)	n.a.	r = -0.8†	n.a.	17
Koho (2011)	93 (60)	44.0 (17-68)	Chrornic pain	n.a. (TSK-17)	n.a. (LTPAQ)	6.4 (VAS)	r = 0.10	>0.05	16
Lotzke (2018)	118 (63)	46 (8)	Chronic low back pain	38.1 (TSK-17)	198 min MVPA/week (accelero.)	6.1 (VAS)	n.a.	0.034	17
Luthi (2018)	433 (n.a.)	n.a.	Chronic MSK pain	44.6 (TSK_17)	4.45 (BHPAQ)	4.45 (BPI-S)	r = 0.067†	0.759†	18
Marques-Sule (2022)	117 (51)	56 (12.1)	Heart transplantation	32.5 (TSK-11)	219 MET-min/week (IPAQ)	n.a.	r = -0.32	0.001	16
Miller (2018)	52 (32)	67.4 (5.1)	Healthy Older Adults	18.9 (TSK-17)	6743 steps/day (hip accelero.)	1.4 (QWBS-P)	r = -0.54	<0.001	16
Minetama (2022)	71 (36)	71.6 (5.6)	Lumbar spinal stenosis	24.8 (TSK-11)	3601 steps/day (pedo.)	6.2 (NRS)	r = -0.229	0.055	17
Navarro-Ledesma (2022)	41 (41)	52.6 (8.0)	Fibromyalgia	27.5 (6.9; TSK-11)	29.1 (18.2; GLTEQ)	n.a.	r = -0.059	>0.05	17
Norte (2019)	77 (35)	21.6 (7.8)	Surgery (ACLR)	32.9 (6.0; TSK-17)	72.7 (34.9; GLTEQ)	91.4 (9.2; KOOS-P)	r = -0.312	<0.05	17
Ohlman (2018)	52 (33)	67.4 (5.1)	Older adults	18.8 (4.5; TSK-11)	n.a. (hip accelero.)	n.a.	ρ = -0.29	<0.05	17
Olsson (2014)	81 (12)	40.0 (9.6)	Achilles tendon rupture	35.9 (7.5; TSK-17)	2.9 (1.0; SGPALS)	n.a.	ρ = -0.275	0.013	18
Ozer (2022)	62 (30)	36.8 (6.1)	Asthma	39.6 (5.8; TSK-17)	2249 MET-min/week (1333; IPAQ)	n.a.	r = -0.889	0.001	17
Pazzinatto (2022)	92 (92)	n.a. (18-35)	Patellofemoral pain	35.3 (6.8; TSK-17)	7.8 (1.5; BHPAQ)	5.1 (2.1; VAS)	ρ = -0.14	n.a.	17
Pedler (2018)	103 (74)	39.7 (13.9)	Whiplash injury	26 (TSK-11)	9.9% of active time (8.2; trunk accelero.)	4.0 (2.4; VAS)	r = 0.140	>0.05	16
Priore (2020)	50 (37)	22.4 (3.9)	Patellofemoral pain	36.7 (TSK-17)	3088 MET-min/week (IPAQ)	n.a. (VAS)	r = -0.251†	0.072†	17
Roaldsen (2009)	98 (62)	76 (60-86)	Leg ulcer	12 (FABQ)	2.6 (SGPALS)	1.3 (VRS)	r = -0.39†	n.a.	17

Saulicz (2016)	105 (105)	n.a.	Older adults	45.2 (15.6; KCS)	n.a. (BHPAQ)	n.a.	r = -0.577†	<0.001†	16
Sertel (2021)	163 (76)	71.4 (6.0)	Chronic pain	44.4 (7.7; TSK-17)	171.3 (76.2; PASE)	n.a. (VAS)	r = -0.021	>0.05	17
Spaderna (2020)	61 (13)	67.5 (10.7)	Heart failure	1.5 (FactS)	2332 kcal/day (361; hip accelero.)	n.a.	r = -0.28	<0.05	17
Strandberg (2022)	451†† (n.a.)	n.a.	Cancer	n.a. (TSK-14)	1.3 h MVPA/week (0.8; arm accelero.)	n.a.	r = -0.084†	0.074†	16
Sütçü (2021)	20 (10)	69.8 (9.4)	Parkinson's disease	39.8 (7.4; TSK-17)	3078 steps/day (arm accelero.)	n.a.	n.a.	0.157	16
					2055 kcal/day (475; arm accelero.)			0.013	
Uritani (2020)	167 (105)	62.2 (7.5)	Knee osteoarthritis	12.5 (BFMSO)	7998 steps/day (thigh accelero.)	5.7 (NRS)	r = -0.163†	0.035†	16
Verbunt (2005)	123 (57)	44.1 (10.3)	Subacute low back pain	36.0 (TSK-17)	n.a. (hip accelero.)	4.2 (VAS)	ρ = 0.06	>0.05	17
Wasiuk-Zowada (2022)	80 (60)	45.5 (8.6)	Multiple sclerosis	36.6 (TSK-17)	5.1 (BHPAQ)	3.5 (VAS)	r = -0.363	0.001	16
Yuksel Karsli (2021)	34 (12)	41 (n.a.)	Radiographic SpA	42 (TSK-17)	2203 min LPA/day (1377; hip accelero.)	n.a.	ρ = -0.16	0.929	17
					210 min MPA/day (109; hip accelero.)		ρ= -0.158	0.373	
					0 min VPA/day (3; hip accelero.)		ρ= -0.394	0.021	
	33 (10)	33 (n.a.)	Non-radiographic SpA	36 (TSK-17)	2576 min LPA/day (1858; hip accelero.)		ρ = -0.001	0.997	
					265 min MPA/day (216; hip accelero.)		ρ = 0.013	0.947	
					2 min VPA/day (12; hip accelero.)		ρ = -0.240	0.209	
Zelle et al. (2016)	487 (209)	51.6 (12.5)	Renal transplantation	n.a. (TSK-11)	165 METs-min/day (MLTPAQ & TOAQ)	n.a.	r = -0.22	<0.001	17

Table 1. Sample characteristics of the studies included in the systematic review.

Notes. Accelero. = Accelerometer, ACLR = anterior cruciate ligament reconstruction, BHPAQ = Baecke Habitual Physical Activity Questionnaire (3 – 15), BFMSO = Brief Fear of Movement Scale for Osteoarthritis (6 – 24), BPI-S = Brief Pain Inventory-Severity (1 – 10), COPD = Chronic Obstructive Pulmonary Disease, Corr. = Correlation, CVD = cardiovascular disease, FABQ = Fear-Avoidance Belief Questionnaire (0 – 24), FActS = Fear of Activity in Situations (0 – 30), GLTEQ = Godin Leisure Time Exercise Questionnaire (0 – 119), GRS = Graphic Rating Scale (0 – 10), IPAQ = short form of the International Physical Activity Questionnaire, KCS = Kinesiophobia Causes Scale (0 – 100), KOOS-P = Knee Injury and Osteoarthritis Outcome Score – Pain (0 – 100), LPA = light physical activity, n.a. = not available, MPA = moderate physical activity, MSK = Musculoskeletal, MVPA = moderate-to-vigorous physical activity, NRS = Numeric Rating Scale (maximum score = 0 – 10), OKS = Oxford Knee Score – Pain , PA = Physical Activity, PASE = Physical Activity Scale for the Elderly, Pedo. = Pedometer, r = Pearson's correlation coefficient, ρ = Spearman's correlation coefficient, SF-36 = 36-Item Short Form Survey (0 – 100), QWBS-P = Quality of Well-Being Scale-Pain, SGPALS = Saltin-Grimby Physical Activity Level Scale (1 – 4), SpA = axial spondyloarthritis, TAS = Tegner Activity Scale (0 – 10), TOAQ = Tecumseh Occupational Activity Questionnaire, TSK = Tampa Scale of Kinesiophobia [TSK-17: 17 – 68, TSK-Heart = 17 – 68, TSK-14 = 14 – 56, TSK-13 = 13 – 52, TSK-11 = 11 – 44), UCLA = University of California Los Angeles activity score (1 – 10), VAS = Visual Analog Scale (0 – 10), VPA = vigorous physical activity, VRS = Verbal Rating Scale for pain assessment (0 – 5), † was obtained by email from authors, ††Number of participants used to calculare the correlation, according to the email sent by the authors.

cipants with a neurological (36.0 to 39.8) or surgical condition (32.9) and in healthy adults (18.9 to 39.0).

Forty-three studies reported mean levels of kinesiophobia (Table 1). The studies based on the TSK-17 or TSK-Heart (mean range: 17 to 68) reporting the highest levels of kinesiophobia were those involving participants with a cardiovascular condition (41.4 to 49.7), followed by studies testing participants with arthritis (31.8 to 45.0), chronic pain (30.5 to 44.4), or a pulmonary condition (39.6 to 42). Levels of kinesiophobia were lower in participants with a neurological (36.0 to 39.8) or surgical condition (32.9) and in healthy adults (18.9 to 39.0).

Physical Activity

Thirty-four studies assessed physical activity using a self-reported measure (Table 1). Most of these questionnaire-based studies used the short form of the International Physical Activity Questionnaire (IPAQ-SF) (k = 13[48,49,56,58,60,72,73,75,77,81–83,87], which consists of 6 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 7 days[100]. Other questionnaires were used to assess physical activity, such as the Baecke Habitual Physical Activity Questionnaire[101] (BHPAQ; k = 5[46,54,57,65,85]), the Saltin-Grimby Physical Activity Level Scale[102] (SGPALS; k = 4[53,59,70,92]), the Godin-Shephard Leisure-Time Exercise Questionnaire[103] (GLTEQ; k = 2[66,79]), the Minnesota Leisure Time Physical Activity Questionnaire[104] (MLTPAQ; k = 1[78]), the Physical Activity Scale for the Elderly[105] (PASE; k = 2[68,89]), the Physical Activity Questionnaire for the Elderly[106] (PAQE; k = 1[47]), the Short Questionnaire to Assess Health Enhancing Questionnaires[107] (SQUASH; k = 1[88]) , the Tegner Assessment Scale[108] (TAS; k = 1[45]), and the University of California Los Angeles (UCLA) activity score[109] (k = 1[80]).

Physical activity was also assessed with devices such as accelerometers measuring accelerations in 3 dimensions (k = 15[50,51,55,57,61,62,64,67,69,74,76,84,86,90,91]) and pedometers measuring the number of steps (k = 3[45,71,88]) (Table 1). In most studies, the device was worn at the hip (k = 9[45,57,61,69,74,76,84,90,91]). Other positions included trunk (k = 2[62,67]), arm (k = 2[50,86]), wrist (k = 1[55]), and thigh (k = 1[51]), with three studies not reporting where the device was worn[64,71,88]. Most studies that employed accelerometer-based measures used the ActiGraph (Actigraph, LLC, Pensacola, FL, USA) GT3X+ (k = 4[64,76,90,91]) or wGT3X-BT (k = 1[84]). The other accelerometers were the RT3 (Stayhealthy Inc., Monrovia, CA, USA; k = 3[61,62,69]), the SenseWear Pro3 Armband (BodyMedia, Pittsburgh, PA, USA; k = 2[50,86]), the Activity Sensory Move II (movisens GmbH, Karlsruhe, Germany; k = 1[74]), the LifeShirt (Vivometrics, Inc., Ventura, CA, USA; k = 1[67]), and the ActiWatch (Mini Mitter Co., Inc., Bend, OR, USA; k = 1[55]). The type of accelerometer was not reported in one study[57]. The pedometers were the Digi-Walker SW-200 (New Lifestyles Inc., Lees Summit, MO, USA; k = 2[45,88]) and the Active Style Pro HJA-350IT (Omron Heathcare, Kyoto, Japan; k = 1[71]).

To assess physical activity, the studies used the following outcomes: Score from a questionnaire (e.g., TAS, PAQE, BHPAQ, SGPALS, LTPAQ; k = 18[45–47,52–54,57,59,63,65,66,70,78–80,85,89,92]), MET-min/week (k = 13[48,49,56,58,72,73,75,78,81–83,87,88]), steps per day (k = 7[45,51,57,71,86,88,90]), hours per day or week (k =6[44,50,57,64,83,84]), counts per minute (k = 4[55,57,61,76]), kilocalories per day (k = 2[74,86]), or percentage of active time (k = 1[67]). Five studies used multiple physical activity outcomes[45,57,84,86,88].

Association Between Physical Activity and Kinesiophobia

Thirty-two of the 49 articles reported a correlation estimate of the association between physical activity and kinesiophobia. Twenty-three articles reported a correlation estimate of the association between physical activity and kinesiophobia. Twenty-three articles reported at least one Pearson’s r estimate, eight reported at least one Spearman’s rho estimate, and one reported a Cohen's d. Eleven additional Pearson’s r values were obtained by email from the authors[44–54], for a total of 34 articles including 41 Pearson’s r estimates that were used in the meta-analysis (Table 1).

Study	Total	Weight	Correlation IV, Random, 95% CI
Baez, 2020	40	2.2%	0.18 [-0.14; 0.47]
Pedler, 2018	103	2.5%	0.14 [-0.06; 0.32]
Koho, 2011	93	2.5%	0.10 [-0.11; 0.30]
Luthi, 2022	433	2.7%	0.07 [-0.03; 0.16]
Bahar Ozdemir, 2021	101	2.5%	-0.01 [-0.20; 0.19]
Carvalho, 2017	119	2.6%	-0.02 [-0.20; 0.16]
Sertel, 2021	163	2.6%	-0.02 [-0.17; 0.13]
Assadourian, 2020	123	2.6%	-0.02 [-0.20; 0.16]
Bernard, 2015	121	2.6%	-0.05 [-0.23; 0.13]
Coronado, 2021	248	2.7%	-0.05 [-0.17; 0.08]
Helmus, 2012	53	2.4%	-0.05 [-0.32; 0.22]
Navarro-Ledesma, 2022	41	2.2%	-0.06 [-0.36; 0.25]
Strandberg, 2022	451	2.7%	-0.08 [-0.17; 0.01]
Altug, 2016	112	2.5%	-0.10 [-0.28; 0.09]
Baday-Keskin, 2022	88	2.5%	-0.12 [-0.32; 0.09]
Demirbuken, 2016	99	2.5%	-0.15 [-0.34; 0.05]
Uritani, 2020	167	2.6%	-0.16 [-0.31; -0.01]
Dabek, 2020e	27	2.0%	-0.20 [-0.54; 0.19]
Zelle, 2016	487	2.7%	-0.22 [-0.30; -0.13]
Minetama, 2022	71	2.4%	-0.23 [-0.44; 0.00]
Aykut Selcuk, 2020a	67	2.4%	-0.25 [-0.46; -0.01]
Priore, 2020	50	2.3%	-0.25 [-0.49; 0.03]
Spaderna, 2020	61	2.4%	-0.28 [-0.50; -0.03]
Aykut Selcuk, 2020b	29	2.1%	-0.31 [-0.61; 0.06]
Norte, 2019	77	2.5%	-0.31 [-0.50; -0.09]
Baykal Sahin, 2021	98	2.5%	-0.32 [-0.48; -0.12]
Marques-Sule, 2022	117	2.6%	-0.32 [-0.47; -0.15]
Wasiuk-Zowada, 2022	80	2.5%	-0.36 [-0.54; -0.16]
Roaldsen, 2009	98	2.5%	-0.39 [-0.55; -0.21]
Dabek, 2020d	119	2.6%	-0.41 [-0.55; -0.25]
Dabek, 2020a	72	2.4%	-0.43 [-0.60; -0.22]
Dabek, 2020c	130	2.6%	-0.52 [-0.64; -0.39]
Miller, 2018	52	2.3%	-0.54 [-0.71; -0.31]
Dabek, 2020f	86	2.5%	-0.56 [-0.69; -0.40]
Saulicz, 2016	105	2.5%	-0.58 [-0.69; -0.43]
Dabek, 2020g	15	1.6%	-0.66 [-0.88; -0.23]
Kilinc, 2019	200	2.6%	-0.69 [-0.76; -0.61]
Aydemir, 2022	37	2.2%	-0.77 [-0.88; -0.60]
Knapik 2019	135	2.6%	-0.80 [-0.85; -0.73]
Dabek, 2020b	18	1.8%	-0.87 [-0.95; -0.67]
Ozer, 2022	62	2.4%	-0.89 [-0.93; -0.82]
Total (95% CI)	**4848**	**100.0%**	**-0.31 [-0.42; -0.20]**
Prediction interval			**[-0.78; 0.37]**

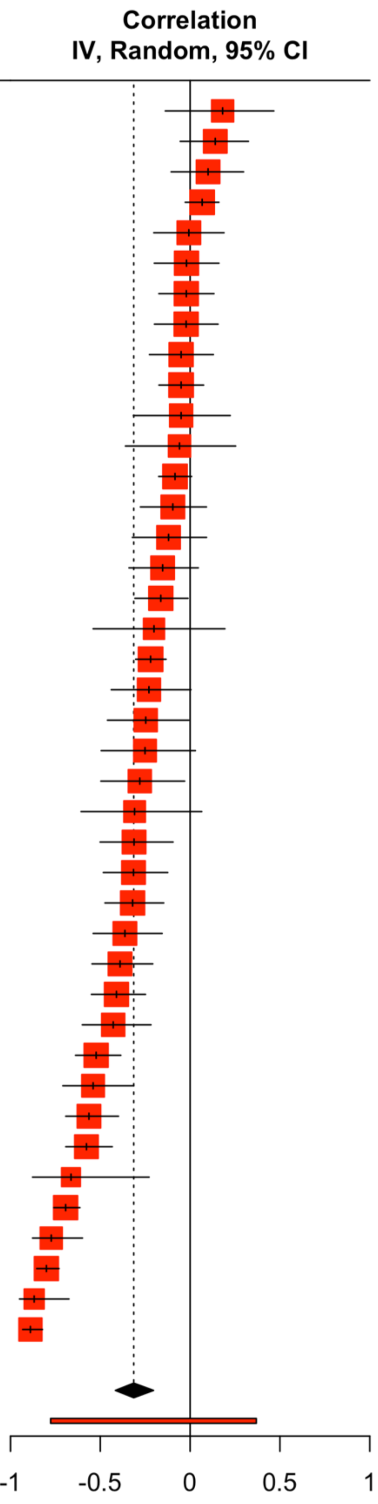

Figure 2. Main meta-analysis: Correlation between kinesiophobia and physical activity (k = 41, n = 4,848). Heterogeneity: $Tau^2 = 0.1204$; $Chi^2 = 490.59$, df = 40 ($P < 0.01$); $I^2 = 92\%$

Notes. 95% CI = 95% confidence interval, IV = Inverse-variance method, Random = Random-effects method.

Pain

Mean pain intensity at rest was reported in 28 out of the 49 articles included in the systematic review. Most studies used the Visual Analog Scale[110] (VAS; k = 11[56,61,63–65,67,69,81,83,85]) or the Numeric Rating Scale[111] (NRS; k = 8[44,48,51,55,57,60,71,76]). Other studies used the Knee Injury Osteoarthritis Outcome Score pain subscale[112] (KOOS-P; k = 3[45,79,80]), Brief Pain Inventory [113] (k = 1[46]), Oxford Knee Score[114] (OKS; k = 1[82]), the Quality of Well-Being Scale – Self-administered Pain Scale[115] (QWBS-P; k = 1[90]), the Short Form 36 bodily pain[116] (SF-36; k = 1[73]), the Graphic Rating Scale[117] (GRS; k = 1[77]), and the Verbal Rating Scale[118] (VRS; k = 1[53]). In the meta-analysis, scores that were not on a 0-100 scale in the initial measure were scaled to that range.

Meta-Analysis

Main Meta-Analysis

Our meta-analysis of 41 studies (n = 4,848) revealed a statistically significant moderate negative correlation between kinesiophobia and physical activity (r = -0.31; 95% confidence interval [95% CI]: -0.42 to -0.20; p < 0.0001; Table 2; Figure 2). However, we observed considerable between-study statistical heterogeneity (Tau^2 = 0.12, 95% CI: 0.08 to 0.22; I^2 = 91.8%, 95% CI: 89.9 to 93.5%), and the prediction interval ranged from r = -0.78 to 0.37, indicating that a moderate positive correlation cannot be ruled out for future studies.

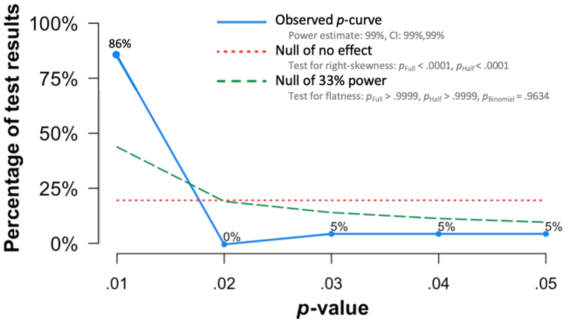

Figure 4. P-curve analysis

Publication Bias Assessment

Egger's regression test showed that the data in the funnel plot was asymmetric (b = -2.85, 95% CI: -5.55 to -0.14, p = 0.046; Figure 3), which may be explained by publication bias, but also by other potential causes, such as different study procedures and between-study heterogeneity[119], which was considerable here. The bias-corrected estimate of the true effect size, calculated using Rücker's limit meta-analysis method, showed that the correlation would remain significant if there was publication bias (r = -0.18; 95% CI: -0.34 to -0.01; p = 0.0378). A total of 41 studies were provided to the p-curve analysis, including 21 (51.2%) studies with p < 0.05 and 18 studies (43.9%) with p < 0.025 (Figure 4). The p-value of the right-skewness test was < 0.0001 for both the half and full curve, suggesting that evidential value was present[120].

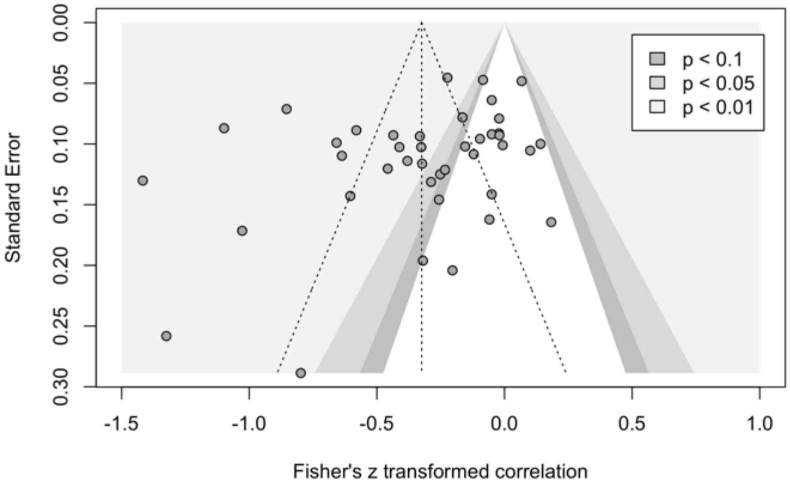

Figure 3. Contour-enhanced funnel plot of the main meta-analysis

	k	n	cor.	95% CI	I^2 (%)	*p*
Main						<.0001
Kinesiophobia and physical activity	41	4848	-.31	[-.42; -.20]	92	
Subgroup: Health status						<.0001
Chronic pain	11	1410	-.03	[-.10; .04]	18	
Cardiovascular	11	958	-.47	[-.59; -.32]	84	
Arthritis	6	588	-.42	[-.69; -.04]	93	
Surgery	4	852	-.12	[-.42; .21]	73	
Older adults	3	278	-.40	[-.86; .40]	91	
Neurological	2	98	-.62	[-1.0; 1.0]	91	
Cancer	1	451	-.08	[-.42; -.20]		
Young adults	1	101	-.01	[-.20; .19]		
Pulmonary	1	62	-.89	[-.93; -.82]		
Acute pain	1	50	-.25	[-.49; .03]		
Subgroup: Physical activity measure						.011
Self-reported	32	3934	-.36	[-.48; -.24]	93	
Device-based	9	914	-.12	[-.28; -.06]	70	
Secondary: rho values						.217
Kinesiophobia and device-based physical activity	5	361	-.10	[-.27; .09]	30	
Subgroup: Physical activity measurement instrument						.014
IPAQ	18	1490	-.43	[-.57; -.26]	90	
Accelerometer	8	1254	-.13	[-.30; .05]	69	
BHPAQ	3	618	-.30	[-.84; .54]	96	
Pedometer	2	111	-.04	[-.99; .99]	76	
MLTPAQ	2	580	-.07	[-.97; .96]	87	
GLTEQ	2	118	-.20	[-.95; .90]	43	
PASE	1	163	-.31	[-.42; -.20]		
PAQE	1	135	-.80	[-.85; -.73]		
Diary	1	123	-.02	[-.20; .16]		
Ad-hoc questionnaire	1	121	-.05	[-.23; .13]		
SGPALS	1	98	-.39	[-.55; -.21]		
UCLA	1	37	-.77	[-.88; -.60]		
Subgroup: Physical activity outcome						<.0001
MET-min/week	19	1977	-.42	[-.56; -.25]	90	
Score	11	1383	-.33	[-.56; -.06]	95	
Steps/day	4	330	-.21	[-.61; .28]	78	
Active time	3	677	.01	[-.27; .29]	52	
Counts/min	3	420	-.04	[-.08; .00]	0	
Kcal/day	1	61	-.28	[-.50; -.03]		
Subgroup: Kinesiophobia measure						.032
TSK-17	21	2257	-.28	[-.43; -.11]	93	
TSK-Heart	8	602	-.59	[-.75; -36]	85	
TSK-11	6	859	-.09	[-.31; .13]	74	
TSK-14	1	451	-.08	[-.17; .01]		
TSK-13	1	248	-.05	[-.17; .08]		
KCS	1	105	-.58	[-.69; -.43]		
FABQ	1	98	-.39	[-.55; -.21]		
FActS	1	61	-.28	[-.50; -.03]		

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

Notes. 95% CI = 95% confidence interval, BHPAQ = Baecke Habitual Physical Activity Questionnaire, Cor. = Correlation estimate, FABQ = Fear-Avoidance Belief Questionnaire, FActS = Fear of Activity in Situations, GLTEQ = Godin Leisure Time Exercise Questionnaire, IPAQ = short form of the International Physical Activity Questionnaire, k = number of studies, KCS = Kinesiophobia Causes Scale, MLTPAQ = Minnesota Leisure Time Physical Activity Questionnaire, n = number of participants, p = p-value for between-group difference, PAQE = Physical Activity Questionnaire for the Elderly, PASE = Physical Activity Scale for the Elderly, SGPALS = Saltin-Grimby Physical Activity Level Scale, TSK = Tampa Scale of Kinesiophobia, UCLA = University of California Los Angeles activity score.

Subgroup Meta-Analyses

The test of subgroup differences between health status measures was possible between studies comprising people with chronic pain (k = 11), cardiovascular condition (k = 11), arthritis (k = 6), and neurological conditions (k = 2), people who had received surgery (k = 4), and older adults (k = 3) (Table 4; Figure 5). We found statistical differences between these studies ($p < 0.0001$). The relationship between kinesiophobia and physical activity was statistically significant only in studies that included participants with cardiovascular disease (r = -0.47; 95% CI: -0.59 to -0.32) and arthritis (r = -0.42; 95% CI: -0.69 to -0.05). The effect of arthritis remained significant when focusing on osteoarthritis (k = 5; r = -0.48; 95% CI: -0.76 to -0.35). Statistical heterogeneity was higher in the studies comprising people with arthritis (I^2 = 92.7%) than the studies comprising people with cardiovascular disease (I^2 = 83.9%).

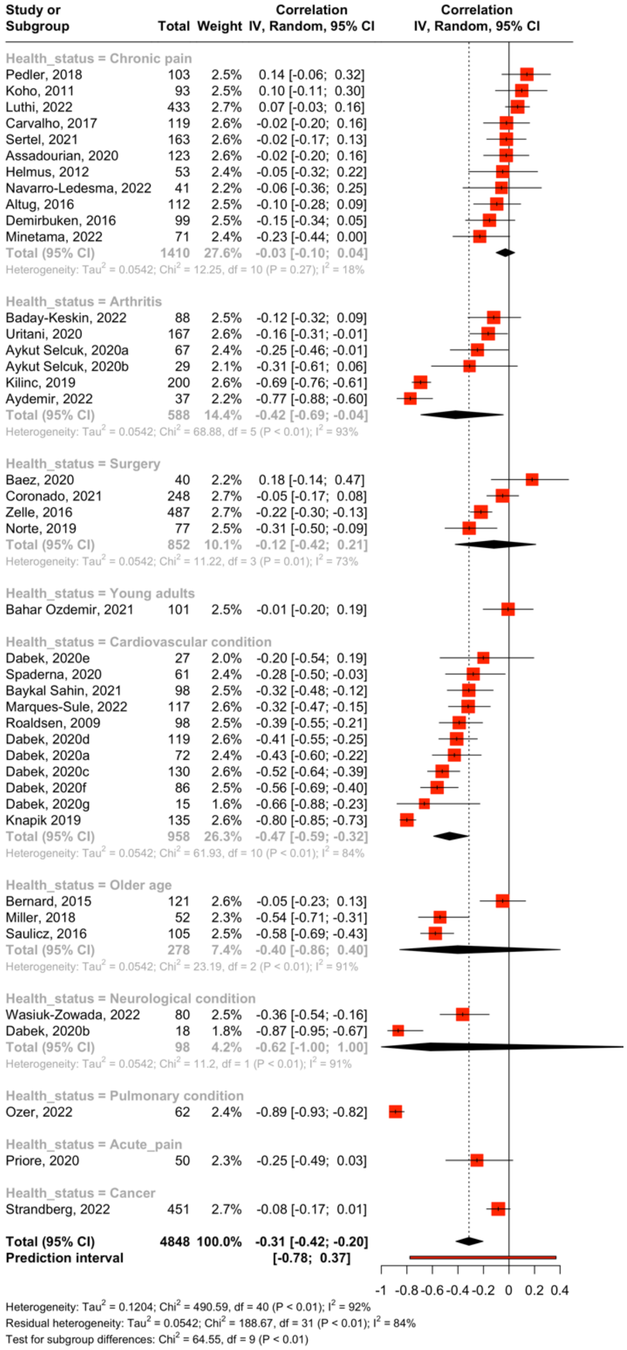

Figure 5. Subgroup meta-analysis: Differences according to health status.

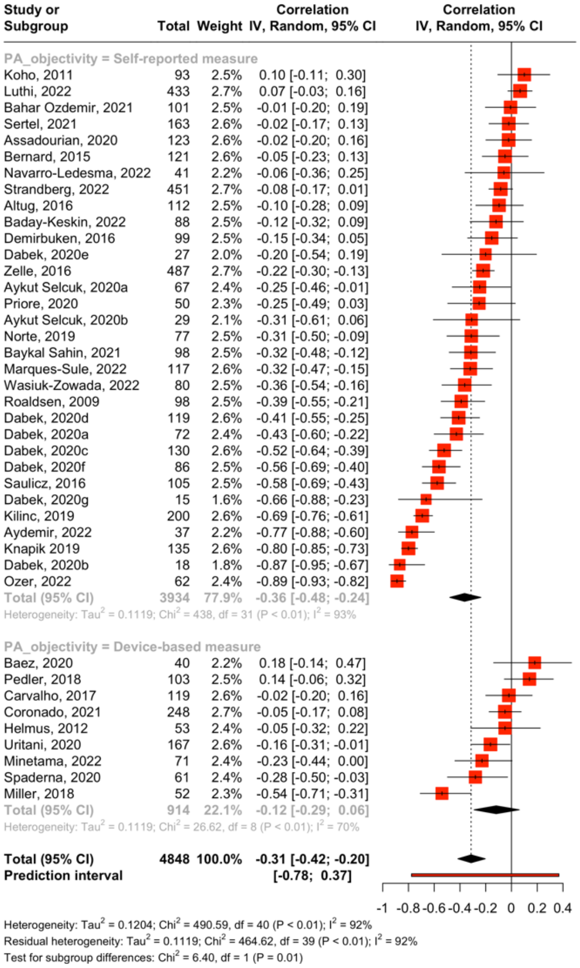

Figure 6. Subgroup meta-analysis: Differences according to physical activity measure (self-report vs. device).

The test of subgroup differences between self-reported (k = 32) and device-based (k = 9) measures of physical activity showed a statistically significant difference ($p < 0.0001$; Table 4), with only the self-reported measures showing a correlation (r = -0.36; 95% CI: -0.48 to -0.24; Figure 6). However, we observed considerable between-study statistical heterogeneity ($I^2 = 92.9\%$). Results of the secondary meta-analysis based on Spearman rho values (k = 5, n = 361) were consistent with this subgroup analysis as they showed no statistical evidence of an association between kinesiophobia and accelerometer-based measures of physical activity (r = -0.10; 95% CI: -0.27 to 0.09; $I^2 = 30.2\%$; p = 0.217; Table 4; Figure 7).

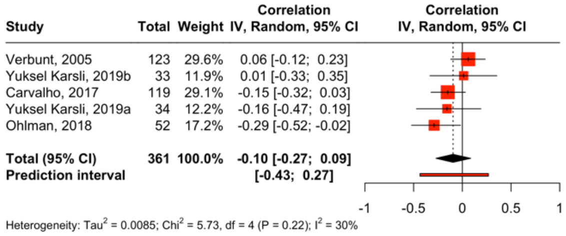

Figure 7. Secondary meta-analysis based on Spearman's rho value of studies using accelerometer-based physical activity.

The test of subgroup differences according to physical activity measurement instruments was possible between studies using the IPAQ (k = 18), BHPAQ (k = 3), MLTPAQ (k = 2), GLTEQ (k = 2), as well as accelerometers (k = 8) and pedometers (k = 2). We found statistical differences between these studies (p = 0.014). The relationship between kinesiophobia and physical activity was statistically significant only in studies that used the IPAQ (r = -0.43; 95% CI: -0.57 to -0.26; Table 4; Figure 8). However, we observed considerable between-study statistical heterogeneity ($I^2 = 89.7\%$).

The test of subgroup differences between physical activity outcomes was possible between studies using MET-min/week, typically from the IPAQ (k = 19), a score from a questionnaire (k = 11), steps/day (k = 4), counts/min (k = 3), and active time in hours per day or week (k = 3) (Table 4; Figure 9). We observed statistical differences between these studies ($p < 0.0001$), with only the studies using the MET-min/week (r = -0.42; 95% CI: -0.56 to -0.26)

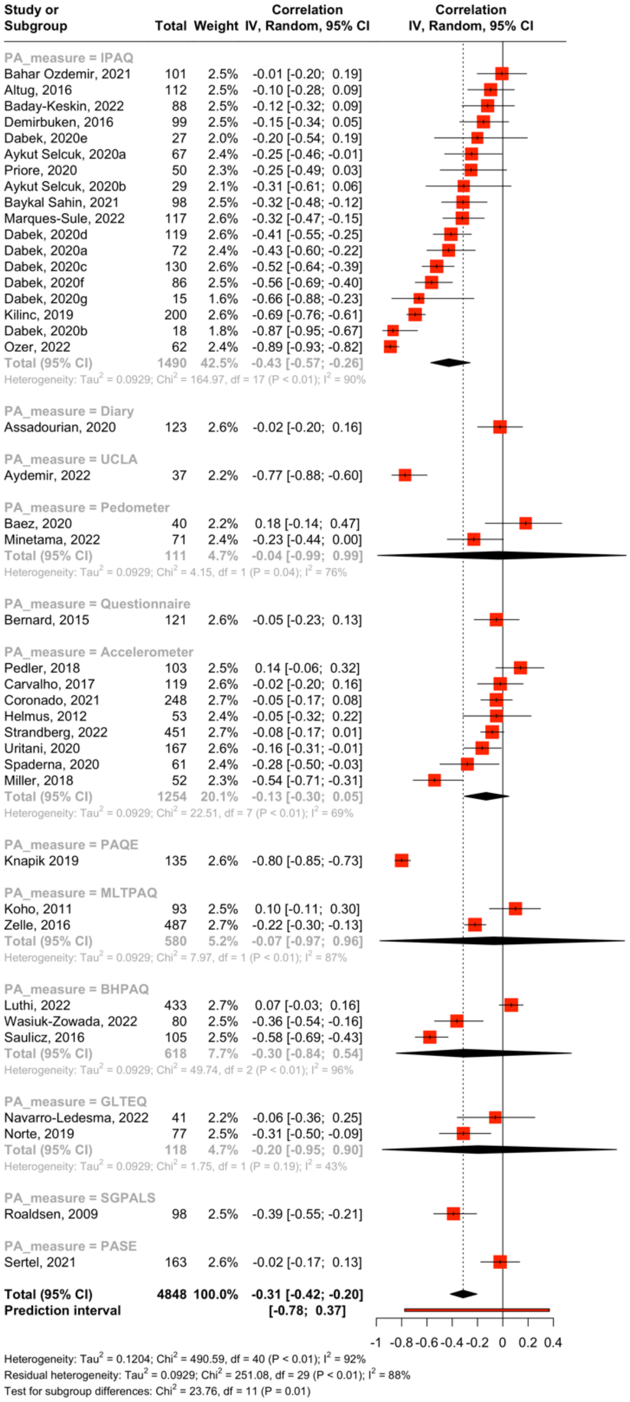

Figure 8. Subgroup meta-analysis: Differences according to physical activity measurement instruments.

Notes: 95% CI = 95% confidence interval, BFMSO = Brief Fear of Movement Scale for Osteoarthritis, FABQ = Fear-Avoidance Belief Questionnaire, FActS = Fear of Activity in Situations, IV = Inverse-variance method, KCS = Kinesiophobia Causes Scale, PA = physical activity, Random = Random-effects method, TSK = Tampa Scale of Kinesiophobia and score outcome (r = -0.33; 95% CI: -0.56 to -0.06) showing a statistical correlation. Heterogeneity was considerable in studies relying on these outcomes (I^2 = 90.1 and 95.1%).

The test of subgroup differences between kinesiophobia measures was possible only for TSK-17 (k = 21), TSK-Heart (k = 8), and TSK-11 (k = 6) (Table 4; Figure 10), with only the former two showing a statistical correlation. The correlation was stronger in studies using the TSK-Heart (r = -0.59; 95% CI: -0.75 to -0.36) than with the TSK-17 (r = -0.28; 95% CI: -0.43 to -0.11). Heterogeneity was lower, albeit substantial to considerable in the studies using TSK-Heart (I^2 = 85.0%) than TSK-17 (I^2 = 92.6%).

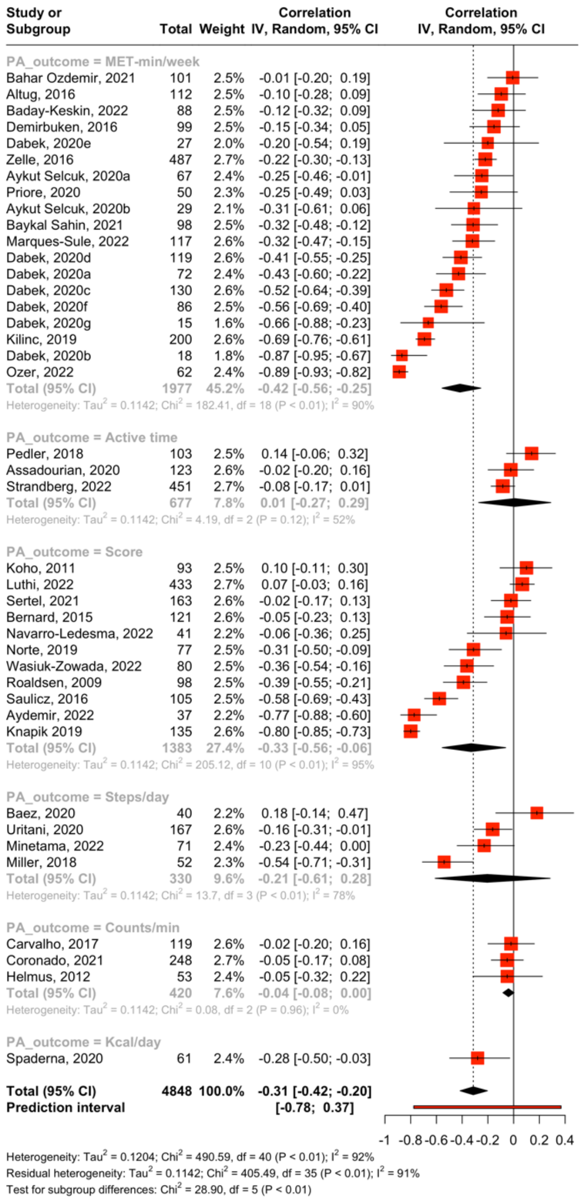

Figure 9. Subgroup meta-analysis: Differences according to physical activity outcome.

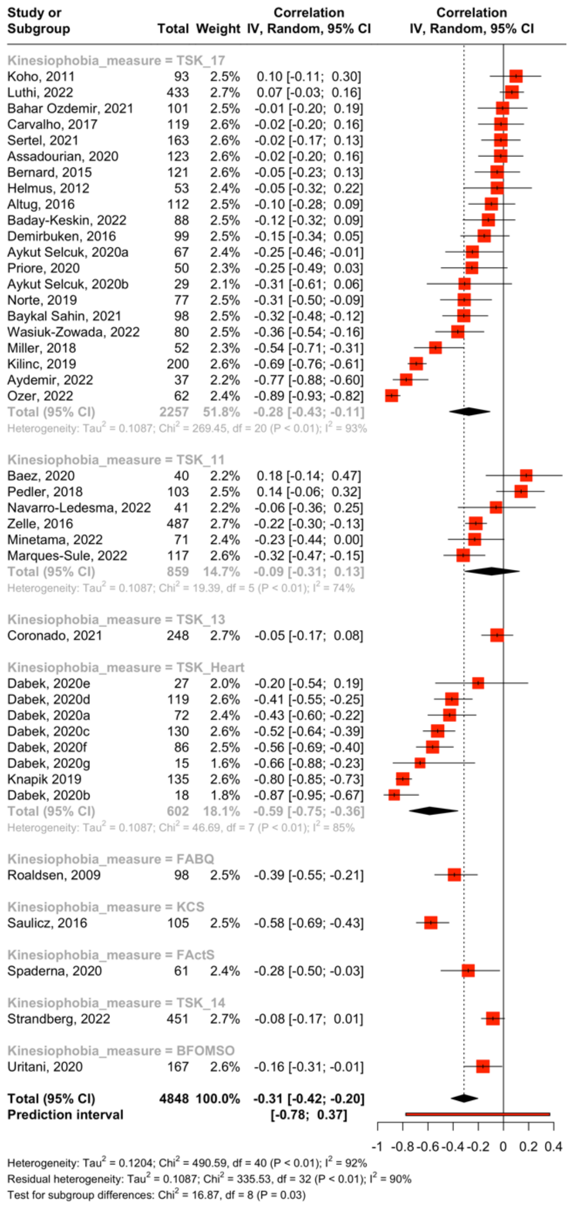

Figure 10. Subgroup meta-analysis: Differences according to kinesiophobia measure.

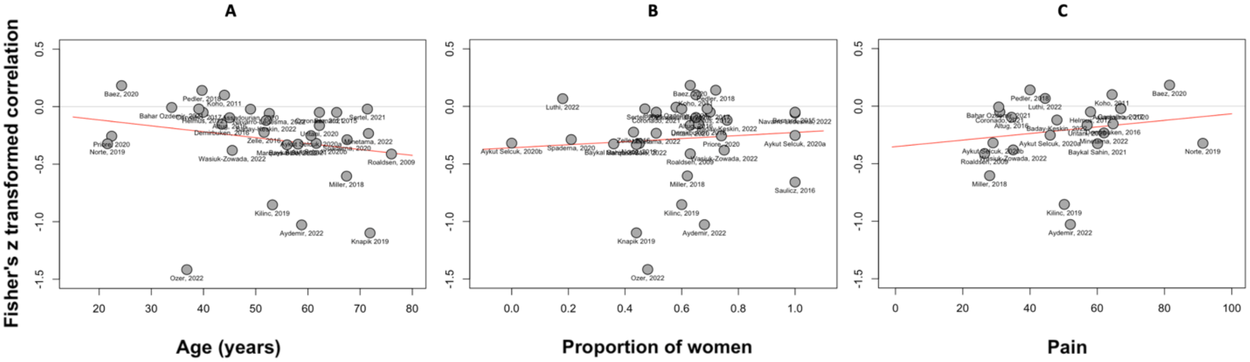

Figure 11. Meta-Regressions testing the influence of age (k = 31) (A), the proportion of women (k = 33) (B), and pain intensity (k = 23) (C) on the correlation estimates of the meta-analysis studies.

Meta-Regressions

Age did not statistically influence the correlation values of the meta-analysis studies (k = 31; p = 0.263) (Figure 11A). Due to the similar I^2 between this meta-regression and the main meta-analysis (92.6% vs. 91.8%, respectively), the addition of age as a predictor did not explain the considerable heterogeneity observed between study correlations. The R^2 revealed that only 1.0% of the differences between study correlations could be explained by age. Similarly, the proportion of women (k = 33; Figure 11B) and the mean level of pain in the studies (k = 23; Figure 11C) did not influence correlation values. The R^2 revealed that these variables explained less than 0.01% of the differences between study correlations.

Sensitivity Analysis

The meta-regression by AXIS score (k = 41) showed that a study's quality did not influence correlation values. The R^2 revealed that this variable explained less than 0.01% of the differences between study correlations. However, it should be noted that there was very little variation in axis scores with all scores ranging between 16 and 18.

Discussion

The main objective of this study was to systematically review and meta-analyze the direct relationship between kinesiophobia and physical activity. In addition, we examined the influence of potential moderators. To our knowledge, this is the first review of its kind on this emerging research topic.

Patients with Arthritis, Cardiovascular, and Pulmonary conditions

The meta-analysis (k = 41, n = 4,848) showed a moderate negative correlation between kinesiophobia and physical activity. This result is consistent with our hypothesis and the dual models of physical activity[23,24,26]. According to the theoretical models, this main result suggests that the fear of movement characteristic of kinesiophobia triggers an impulse to avoid physical activity behaviors, which contributes to the maintenance or exacerbation of the initial fear. Accordingly, kinesiophobia and physical inactivity would be self-perpetuating or even self-reinforcing.

Our results suggest that patients with cardiovascular or arthritic conditions may be at greater risk for this negative relationship between kinesiophobia and physical activity than those with other conditions, such as chronic pain. This latter finding was surprising because fear of pain is a key component of kinesiophobia, appearing in 10 of the 17 items on the TSK-17 and TSK-Heart scales, and reinforces the importance of considering the multidimensional nature of kinesiophobia, which also reflects fear of injury and fear of worsening a health condition. Although our results showed no evidence of an association between kinesiophobia and physical activity in other health conditions such as cancer, acute pain, post-surgery, neurological and pulmonary conditions, these effects cannot be fully ruled out, as the lack of statistical significance could be explained by a lack of statistical power in these subgroup meta-analyses including fewer studies (k = 1 to 5). Of note, only one study examined the relationship between kinesiophobia and physical activity in people with a pulmonary condition (i.e., chronic obstructive pulmonary disease, COPD), but this study was the one that reported the highest correlation (r = -0.89; 95% CI: -0.93 to -0.82), suggesting that this population should also be closely monitored for kinesiophobia.

No Evidence Based on Objective Measures of Physical Activity

Importantly, the results showed that the negative association between kinesiophobia and physical activity was statistically significant in studies using self-report measures (e.g., IPAQ), but not in studies using device-based measures (i.e., accelerometers or pedometers). This difference persisted in analyses that further disaggregated the physical activity measures (i.e., specifying the types of questionnaires and devices) and tested the effect of the different outcomes. The secondary analysis based on Spearman's rho values further supported these results as it provided no evidence suggesting an association between kinesiophobia and device-based measures of physical activity, albeit in a small number of studies. Because device-based measures of physical activity are more valid and reliable than self-reported measures, these findings call into question the robustness of the relationship between kinesiophobia and physical activity. Therefore, additional studies relying on device-based measures are required to confirm the negative associations we observed between kinesiophobia and physical activity we observed in people with a cardiovascular, arthritis, or pulmonary condition, which were mainly based on self-reported measures.

Pain vs. Fear

Contrary to our expectations, we found no statistical evidence showing that the level of actual pain intensity at rest influenced the effect of kinesiophobia on physical activity, despite the substantial number of studies included in this analysis (k = 23). This result is consistent with the weak relationship that has been shown between kinesiophobia and pain[121], further suggesting that it is not the actual pain that prevents physical activity, but the fear of triggering pain, injury, or aggravating an underlying condition. However, our results also suggest that the effect of pain may be better assessed by pain history (e.g., pain duration in months) or pain intensity during exercise. The absence of significant effects in the group of studies based on shorter versions of the TSK suggests that the items removed from these versions may be important to accurately assess kinesiophobia.

Kinesiophobia Measure

Studies using the TSK-17 or the TSK-Heart to assess kinesiophobia both showed a statistically significant relationship with physical activity. This consistency is not surprising as these two measures are very similar. They differ only in specific vocabulary that makes the TSK-Heart specific to individuals with a cardiac condition (e.g., "heart problem" instead of "pain" and "injury") and the TSK-17 more broadly applicable to different populations. In addition, the stronger correlation observed in studies using the TSK-Heart compared with the TSK-17 is consistent with our results showing stronger correlations in studies of people with a cardiovascular condition.

Limitations and Strengths

The results of this systematic review and meta-analysis should be considered in light of several limitations. Some of our results showed considerable heterogeneity, which may be explained by the diversity of the methods used to assess physical activity (questionnaires vs. accelerometers vs. pedometers), the instruments used in these methods (10 different questionnaires, 8 different accelerometers and pedometers), and the physical activity outcomes (n = 9), but also by the type of questionnaires used to assess kinesiophobia (n = 9). This heterogeneity suggests that the measures of kinesiophobia and physical activity used in the literature reflect different dimensions of these two constructs. For example, self-reported measures of physical activity do not accurately reflect actual levels of physical activity[122]. Only articles published in English were included. Inclusion of articles published in other languages may have influenced the results. Only 11 of the 58 authors we contacted (19 %) shared their estimates or data with us, which is more than reported in previous literature[123]. Including these missing data may have had an impact on the results. However, these limitations are counterbalanced by several strengths including the preregistration of our work, a substantial number of studies in the meta-analysis, as well as the assessment and correction for publication bias.

Conclusions

Higher levels of kinesiophobia were moderately associated with lower levels of physical activity, especially in people with a cardiovascular, arthritis, and pulmonary condition, and when self-reported physical activity was used. According to theoretical models, this relationship between kinesiophobia and physical activity results from automatic processes that may be self-reinforcing and should therefore not be overlooked. However, there was considerable heterogeneity between studies, and the lack of evidence based on objective measures of physical activity calls for cautious conclusions about this potential relationship. In sum, our results suggest that kinesiophobic patients have only a moderate, if any, risk of being more physically inactive than other patients. Therefore, more evidence is required to determine the impact kinesiophobia should have on therapeutic decisions when aiming to reduce physical inactivity[11]. Further studies using device-based measures of physical activity are needed to confirm our findings and to understand the factors and mechanisms that influence the potential relationship between kinesiophobia and physical activity.

Article Information

Data and Code Availability

According to good research practices[30], the dataset, R Markdown script, and supplemental material are freely available in Zenodo: https://doi.org/10.5281/zenodo.8216112[124]

Authorship Contribution Statement

Based on the Contributor Roles Taxonomy (CRediT)[125,126] individual author contributions to this work are as follows:

- **Miriam Goubran:** Conceptualization; Methodology (Systematic Review); Investigation; Writing – Original Draft; Writing – Review and Editing.
- **Ata Farajzadeh:** Investigation; Writing – Review and Editing.
- **Ian M. Lahart:** Methodology (Meta-Analysis); Formal Analysis; Visualization; Data Curation; Writing – Original Draft; Writing – Review and Editing.
- **Martin Bilodeau:** Conceptualization; Methodology (Systematic Review); Writing – Original Draft; Writing – Review and Editing; Supervision; Project Administration.
- **Matthieu P. Boisgontier:** Conceptualization (Lead); Methodology; Investigation; Formal Analysis; Data Curation; Visualization; Writing – Original Draft (Lead); Writing – Review and Editing; Supervision; Project Administration; Funding Acquisition.

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Conflict of Interest Disclosure

The other authors declare that they have no financial conflict of interest related to the content of this article. Matthieu P. Boisgontier is the founder, representative, and manager of Peer Community In (PCI) Health & Movement Sciences (https://healthmovsci.peercommunityin.org/about), a free and transparent peer review service provided by a community of researchers who review and recommend preprints. He is a former co-chair and current member of the Society for Transparency, Openness, and Replication in Kinesiology (STORK; https://storkinesiology.org), current editor-in-chief for Communications in Kinesiology (https://storkjournals.org/index.php/cik), and associate editor for the European Rehabilitation Journal (https://rehab-journal.com), both of which are Diamond Open Access journals publishing articles in the field of health and rehabilitation sciences.

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