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Review

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Impact of Physical Activity in Cardiovascular and Musculoskeletal Health: Can Motion Be Medicine?

Gannon L. Curtis[a], Morad Chughtai[a], Anton Khlopas[a], Jared M. Newman[a], Rafay Khan[b], Shervin Shaffiy[c], Ali Nadhim[b], Anil Bhave[d], Michael A. Mont[a, e]

Abstract

Physical activity is a well-known therapeutic tool for various types of medical conditions, including vasculopathic diseases such as coronary artery disease, stroke, type 2 diabetes, and obesity. Additionally, increased physical activity has been proposed as a therapy to improve musculoskeletal health; however, there are conflicting reports about physical activity potentially leading to degenerative musculoskeletal disease, especially osteoarthritis (OA). Additionally, although physical activity is known to have its benefits, it is unclear as to what amount of physical activity is the most advantageous. Too much, as well as not enough exercise can have negative consequences. This could impact how physicians advise their patients about exercise intensity. Multiple studies have evaluated the effect of physical activity on various aspects of health. However, there is a paucity of systematic studies which review cardiovascular and musculoskeletal health as outcomes. Therefore, the purpose of this review was to assess how physical activity impacts these aspects of health. Specifically, we evaluated the effect of various levels of physical activity on: 1) cardiovascular and 2) musculoskeletal health. The review revealed that physical activity may decrease cardiovascular disease and improve OA symptoms, and therefore, motion can be considered a “medicine”. However, because heavy activity can potentially lead to increased OA risk, physicians should advise their patients that excessive activity can also potentially impact their health negatively, and should be done in moderation, until further study.

Keywords: Physical activity; Cardiovascular health; Musculoskeletal health

Introduction

Physical activity is a well-known therapeutic tool for various types of medical conditions [1]. Regular exercise has been shown to have protective effects and benefits in vasculopathic diseases such as coronary artery disease, stroke, type 2 diabetes, and obesity [2]. As the United States population grows older, diseases, such as coronary artery disease and osteoarthritis (OA), will increase in prevalence [3]. Furthermore, aging coincides with physical frailty and functional limitations, which can pose a marked burden on families and healthcare systems [4, 5]. This has brought a demand to improve the aging population’s health and quality of life. Additionally, increased physical activity has been proposed as a therapy to improve musculoskeletal health; however, there are conflicting reports about physical activity potentially leading to degenerative musculoskeletal disease, especially OA [6].

Although physical activity is known to have its benefits, it is unclear as to what amount of physical activity is the most advantageous. Currently, the American Academy of Orthopaedic Surgeons guidelines recommend (strong recommendation) that patients who have symptomatic knee OA engage in quadriceps strengthening and low impact aerobic exercise [7]. However, too much, as well as not enough exercise can have negative consequences, as extensive physical activity has been shown to increase the risk of diseases, such as OA, compared to lower activity levels [8]. This could impact how physicians advise their patients with regard to exercise intensity. Although multiple studies have been conducted to evaluate the effect of physical activity on various aspects of health, there is a paucity of systematic studies which review effects of cardiovascular and musculoskeletal health as outcomes.

It is important to understand how we can maximize the benefits and minimize the risks associated with physical activity. Additionally, it is imperative to analyze the level of physical activity to understand the appropriate level that is beneficial. Therefore, the purpose of this review was to assess how physical activity impacts health. Specifically, we evaluated the effect of various levels of physical activity on: 1) cardiovascular disease and mortality; 2) the development of musculoskeletal disease (OA); and 3) patients who have baseline OA.

Methods

A pair of literature searches were conducted to identify clinical studies that assessed how physical activity levels affect cardiovascular and musculoskeletal health. We utilized the following search engines: PubMed, EBSCOhost, Ovid, and Embase.

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[a]Department of Orthopaedic Surgery, Cleveland Clinic, Cleveland, OH, USA
[b]Raritan Bay Medical Center, Perth Amboy, NJ, USA
[c]St. Georges University School of Medicine, True Blue, Grenada, West Indies
[d]Sinai Hospital of Baltimore, Baltimore, MD, USA
[e]Corresponding Author: Michael A. Mont, Department of Orthopaedics, Cleveland Clinic, 9500 Euclid Ave. A40, Cleveland, Ohio 44195, USA. Email: montm@ccf.org and rhondamont@aol.com

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Studies published between January 1996 and June 2016 were evaluated. The following inclusion criteria were applied: full-text reports; randomized crossover studies; randomized controlled trials (RCTs); and studies that had cardiovascular or musculoskeletal health components as an outcome. Exclusion criteria included: studies in which the outcome measures did not include cardiovascular or musculoskeletal health; reports published in languages other than English; and non-trial papers (i.e., expert opinions, reviews).

The first literature search performed was aimed to assess the relationship between physical activity level and cardiovascular health. Reports were identified by using a combination of the following search terms: heart diseases/epidemiology, heart diseases/etiology, heart diseases/prevention and control, exercise, and physical fitness. We initially identified 197 reports. These abstracts were reviewed, along with related citations from references, and 188 articles were excluded for various reasons (not in English, case reports, not related, review articles).

The literature search regarding physical activity level effects on musculoskeletal health was performed using the same methods as performed for cardiovascular health. Abstracts were identified using a combination of the following search terms: osteoarthritis/epidemiology, osteoarthritis/etiology, osteoarthritis/prevention and control, exercise, physical fitness. We initially identified 62 reports. These abstracts were reviewed, along with related citations from references, and 52 articles were excluded for various reasons (not in English, case reports, not related, review articles).

When multiple reports of the same patient population were published by the same author, the study with the larger group of patients and/or the longer follow-up was included in the analysis. The opinion of a second author was sought when a consensus decision could not be reached. This resulted in 19 studies for evaluation (nine for cardiovascular and 10 for OA) for analysis.

Results

Physical activity and cardiovascular health

Several studies correlated leisure time physical activity levels to incidence of cardiovascular disease and/or mortality (Table 1) [9-17]. Three of nine of these studies analyzed their findings based on gender, and one of nine studies described their findings based on race. The remaining five studies evaluated their entire cohort without focusing on any particular stratifications.

A prospective cohort of 83,034 Japanese citizens were followed by Inoue et al [9] for a mean of 8.7 years in order to establish a relationship between physical activity levels and all-cause mortality. Subjects were asked about the amount of time they performed heavy physical work (none, < 1 h, ≥ 1 h), were sedentary (< 3 h, 3 - 8 h, ≥ 8 h), or stood and walked (< 1 h, 1 - 3 h, ≥ 3 h). The data were then transferred into metabolic equivalent (MET) scores with four groupings: lowest, second, third, and highest MET h/day. For men and women, there was an inverse relationship between heart disease risk and MET h/day (men $P_{trend} < 0.001$; women $P_{trend} = 0.001$). Patel et al [10] prospectively followed a cohort of 123,216 participants for an average of 13.1 years to examine time spent sitting versus being physically active and relate it to mortality. Patients were asked how much time they spent sitting and how many hours per week they are doing various physical activities. They observed that there was an increased risk of cardiovascular mortality with higher rates of sitting reported (men $P_{trend} = 0.0007$; women $P_{trend} < 0.0001$), and there was a decrease in cardiovascular mortality with higher levels of physical activity (men $P_{trend} = 0.001$; women $P_{trend} < 0.0001$). Kim et al [11] looked at a prospective group of 134,596 subjects who were followed for an average of 13.7 years to assess how time spent sitting effects mortality. Interestingly, the authors found that total time spent sitting per day did not correlate with mortality in men, but women who sat more than 10 total hours per day have an increased risk of cardiovascular mortality (hazard ratio (HR): 1.19; P < 0.01). Furthermore, a sub-category of participants who sit and watch at least 5 h of television per day were found to be at a higher risk of cardiovascular mortality (P < 0.01).

Matthews et al [12] designed a prospective study to identify the effects that physical activity and a sedentary lifestyle have on mortality in black adults compared to white adults. A total of 63,308 participants were recruited, filled out a questionnaire on physical activity levels and were then followed over a 6.4-year period. The authors found a meaningful reduction in cardiovascular mortality in black (HR: 0.81; 95% CI: 0.67 - 0.98) and white (HR: 0.69; 95% CI: 0.49 - 0.99) adults who were in the highest activity level. In contrast, blacks who were considered the most sedentary (> 12 h/day) did not show an increased risk in cardiovascular disease, whereas white men who were in that same group did have an increase in cardiovascular mortality (HR: 2.18; 95% CI: 1.34 - 3.54), suggesting that this may vary among different races.

Additionally, Matthews et al [13] performed a prospective study with 240,819 participants who were followed for a mean of 8.5 years. The authors wanted to correlate time spent sitting or watching television with overall mortality, and adjusted for amounts of moderate-heavy physical activity per week. Those who reported the most sedentary hours per day (≥ 7 h) had a greater risk of dying from cardiovascular disease (HR: 1.85; 95% CI: 1.56 - 2.21) as compared to those who reported the less sedentary hours per day (< 1 h). The analysis also revealed that when highly active patients (i.e., high levels of moderate-to-vigorous physical activity more than 7 h/week) sit and watch television for a minimum of 7 h/day, there was an associated increased risk of cardiovascular mortality compared to similar patients who sit and watch for less than 1 h/day (HR: 2.00; 95% CI: 1.33 - 3.00)., which is similar to the findings in the Patel et al [10] study. Katzmarzyk [14] followed 16,586 subjects in a prospective study that looked at how long Canadian adults (≥ 18 years old) stand throughout the day and the effect that this has on mortality. The subjects were placed into four groups based on self-reported answers: no standing, standing one-fourth of the day, half of the day and most of the day. There was a significant trend between decreases in cardiovascular mortality with increased time standing per day ($P_{trend} = 0.02$). Furthermore, A Danish study conducted by

Table 1. Physical Activity and Cardiovascular Health [9-17]

Author/ year	Subjects	N	Study type	Follow-up	Activity description	Outcomes
Inoue et al, 2008 [9]	Japanese citizens 45 - 74 years of age	83,034	Cohort	Mean 8.7 years	Daily time spent on three types of physical activity: heavy physical activity, sedentary activity, and walking and standing	Physical activity significantly reduced the risk of cardiovascular disease (hazard ratio: lowest METS* = 1, second METS = 0.77, third METS = 0.62, highest METS = 0.63; P < 0.001)
Patel et al, 2010 [10]	USA 50 - 74 years of age	123,216	Cohort	Max. 14 years	Daily time spent sitting and time spent on physical activity	Time spent sitting was associated with a higher risk of cardiovascular disease mortality. There was a statistically significant inverse relationship between physical activity and cardiovascular disease mortality (P < 0.001)
Matthews et al, 2012 [13]	USA 50 - 71 years of age>	240,814	Cohort	8.5 years	Daily time spent on: television viewing, overall sitting, and moderate-vigorous physical activity (MVPA)	Those reporting ≥ 7 h of TV viewing had almost twice the risk of cardiovascular mortality (HR: 1.85; 95% CI: 1.56 - 2.20), as compared to those reporting < 1 h of TV viewing after adjustment for MVPA. After adjustment for BMI, those reporting ≥ 7 h of TV viewing were at higher risk of cardiovascular mortality (HT: 1.62; 95% CI: 1.37 - 1.93)
Kim et al, 2013 [11]	USA 45 - 75 years of age	134,596	Cohort	13.7 years	Daily time spent sitting watching TV, sitting in other leisure activities; in a car/ bus; at work; and at meals)	The longer time spent sitting watching TV (510 h/day vs. < 5 h/day) is associated with an increased risk of cardiovascular mortality (men: HR: 1.19; 95% CI: 1.10 - 1.129; women; HR: 1.32; 95% CI: 1.21 - 1.44)
	Canada 18 - 90 years of age	16,586	Cohort	12 years	Daily time spent standing: none of the time, one-fourth of the time, half of the time, three-fourth of the time, almost all of the time.	There was a statistically significant inverse relationship between successive levels of daily standing and cardiovascular mortality (HR: 1.0, 0.82, 0.84, 0.68, 0.75; P = 0.02 for standing none of the time, one-fourth of the time, half of the time, three-fourth of the time, almost all of the time).
Matthews et al, 2014 [12]	USA 40 - 79 years of age	63,308	Cohort	6.4 years	Daily time spent performing light, moderate, and strenuous physical activity. In addition exercise and sports participation was assessed. Time spent sitting in a car or a bus, work, viewing TV, using a computer, and other activities. Physical activity was converted to estimates of METS.	Black adults who had the highest level of physical activity had lower risk of death from cardiovascular disease (HR: 0.81; 95% CI: 0.67 - 0.98). White adults (HR: 0.69; 95% CI: 0.49 - 0.99).
Bjork Petersen et al, 2014 [15]	Denmark 18 - 99 years of age	71,363	Cohort	5.4 years	Daily time spent sitting was assessed. In addition, various levels of physical activity were evaluated (vigorous, moderate, light, and inactive).	Those who spent more than 10 h/day compared to less than 6 h/ day sitting had higher risk of developing MI (HR: 1.38; 95% CI: 1.01 - 1.88) but not CHD (HR: 1.07; 95% CI: 0.91 - 1.27). Those who spent less than 6 h/day sitting and being physically active compared to those who spent more than 10 h/day sitting and being physically inactive had lower risk of developing MI (HR: 1.8; 95% CI: 1.15 - 2.82) and coronary heart disease (HR: 1.42; 95% CI: 1.11 - 1.81).
Dunstan et al, 2010 [16]	Australia ≥ 25 years	8,800	Cohort	6.6 years (median)	Daily time spent viewing television was assessed. Adjustments for age, sex, waist circumference, and exercise were made.	The hazard ratio for each additional 1 h of TV time per day was 1.18 (95% CI: 1.03 - 1.35) for cardiovascular mortality. When comparing TV time of < 2 h per day the hazard ratios for cardiovascular mortality were 1.19 (95% CI: 0.72 - 1.99) for ≥ 2 h per day and 1.80 (95% CI: 1.00 - 3.25) for ≥ 4 h per day.
Wijndaele et al, 2011 [17]	UK	13,197	Cohort	9.5 years	Daily time spent viewing television was assessed. Adjustments for gender, age, education, smoking, alcohol, medication, diabetes history, family history of cardiovascular disease and cancer, BMI, and physical activity energy expenditure (PAEE)	An increase of 1 h per day of TV time was associated with a hazard ratio of 1.07 (95% CI: 1.01 - 1.15) for cardiovascular mortality.

*Metabolic equivalents of task.

Bjork Petersen et al [15] looked at 71,363 participants to find if coronary heart disease (CHD) and myocardial infarctions (MI) rates were effected by the amount of time spent sitting. The authors showed that sitting more throughout the day (≥ 10 h versus < 6 h) leads to a significant increase in risk for MI (HR: 1.38; P = 0.05), but the relationship to CHD is not defined (HR: 1.07; P = 0.59). They also indicated that participants who sat more and were less active had higher rates of MI (HR: 1.8; 95% CI: 1.15 - 2.82) and CHD (HR: 1.42; 95% CI: 1.11 - 1.81) compared to those who sat less and were more active. Dunstan et al [16] conducted a prospective study in Australia that followed 8,800 individuals for an average of 6.6 years to assess the effect that television viewing time had on mortality. The authors found that individuals who watched more than 4 h of television per day had higher risks of cardiovascular disease (HR: 1.8; 95% CI: 1.00 - 3.25) compared to individuals who watched less than 2 h/day. They also calculated a cardiovascular disease HR of 1.18 (95% CI: 1.03 - 1.35) for every 1 h increment in television viewing per day. Similarly, a prospective cohort of 13,197 subjects were followed by Wijndaele et al [17] for a mean of 9.5 years. This study was designed to determine how television viewing related to mortality rates. These authors established that each 1 h increase in television viewing time led to increased cardiovascular mortality (HR: 1.07, 95% CI: 1.01 - 1.15).

In summary, although one of three studies on gender demonstrated a benefit in women only, it appears there is a benefit for both genders. In the study discussing race, there appears to be a minimal effect of race on outcomes. The five reports that did not stratify their findings all demonstrate that increased physical activity and decreased leisure time are associated with improved cardiovascular outcomes.

Physical activity and musculoskeletal health

Multiple studies assessed the relationship between physical activity level and the development of OA (Table 2) [18-27]. There were four studies that described OA as a primary outcome and six that described patients who had OA at baseline.

OA as a primary outcome

Of the four studies that described OA as a primary outcome, one described only symptomatic OA (SOA), and three described both symptomatic and radiographic OA (ROA). Plotnikoff et al [18] performed a cross-sectional study of 1,808 participants in which they collected self-reports of OA and activity levels followed by an in-person clinical assessment for OA. The study showed that subjects who report standing or walking throughout their day have a decrease in hip OA (odds ratio (OR): 0.5; P = 0.038) as well as those who carry/lift light loads throughout their day (OR: 0.45; P = 0.037). All activity levels did not significantly increase or decrease the risk of knee OA, and heavy workloads did not significantly increase or decrease the risk of hip OA. Obesity (body mass index (BMI) ≥ 30) was significantly correlated to an increase in knee (OR: 4.37; P < 0.001) and hip (OR: 2.52; P = 0.018) OA.

Felson et al [19] conducted a prospective study of 1,279 patients to determine the long-term outcomes that exercise has on the development of OA. Their study revealed that no type of exercise (walking, jogging, or frequent working up a sweat) was related to an increase or decrease in the risk of developing SOA, ROA or joint space loss. Even the group that reported walking more than 6 miles a week only had an OR of 1.10 when compared to those who did not walk. Furthermore, BMI was assessed and also failed to show a significant correlation to the risk of developing OA. In a retrospective cross-sectional study of 2,637 osteoarthritis initiative (OAI) participants, Lo et al [20] used radiographs, symptom assessments and physical activity surveys to evaluate an association between a history of running and OA. Using an adjusted OR of current runners and previous runners compared to non-runners, they found that the presence of knee pain (OR: 0.76, 0.82; P = 0.02) and SOA (OR: 0.71, 0.88; P = 0.03) were reduced in subjects with a history of running. There was no significant difference found between the groups in regards to ROA (OR: 0.91, 0.98; P = 0.5).

A prospective cohort study of 470 patients was performed by McAlindon et al [21] to evaluate the incidence of ROA and SOA related to the intensity and amount of physical activity per day. They found that heavy physical activity led to a significant increase in ROA (OR: 1.3/h; P = 0.006). The results for SOA were similar but a small sample prevented a significant outcome.

In summary, it appears that physical activity can lead to improvement in musculoskeletal health, notably, OA. For patients who do not have OA at baseline, all four studies describe some sort of benefit of activity for SOA. However, with regard to ROA, two of the three studies describe physical activity not effecting radiographs, and one study demonstrating heavy physical activity to progressive ROA.

Patients with baseline OA

There were six studies that described the effects of physical activity in patients who already have a diagnosis of OA at baseline (Table 2). Five of the six studies described symptomatic and functional outcomes, and one study described radiographic outcomes.

Jan et al [22] performed a randomized control study of 98 subjects with knee OA and assessed them for pain, function, walking time and muscle torque after placing them in one of three exercise regimens (high-resistance, low-resistance, and no exercise) for 8 weeks. Both exercise groups improved across all variables after 8 weeks compared to when they began (P < 0.05), and both exercise groups significantly improved across all variables when compared to the control (no exercise) group (P < 0.008). However, there was not a difference between the high- and low-resistance groups.

Similarly, in an RCT conducted by Mangione et al [23], 39 adults with knee OA were allocated into high-intensity and low-intensity stationary cycling groups in order to analyze the effects that this intervention had on function, gait, pain, and aerobic capacity. The authors found that both groups had significant improvements in chair rise time (P < 0.001), 6-min

Table 2. Physical Activity and Osteoarthritis [18-27]

Author/year	Subjects	N	Study type	Follow-up	Intervention	Outcomes
Lo et al, 2016 [20]	Osteoarthritis initiative (OAI) participants	2,637, 55.8%, female	Retrospective cross-sectional	8 years	Knee X-ray readings, symptom assessments and lifetime physical activity surveys. Compared those who ran and those who did not run.	Odds ratio: pain 0.83 and 0.71 ($P = 0.002$), radiographic OA 0.83 and 0.78 ($P = 0.01$), symptomatic OA 0.81 and 0.64 ($P = 0.0006$). There is no increased risk of OA in self-selected runners.
Kwee et al, 2016 [27]	OAI participants with dAB at the cMF at baseline	51 M, 49 F	Cohort	2 years	Effect of physical activity on progression of knee OA using 2-year follow-up MRI.	No association between physical activity and 2-year MTFC cartilage change.
Foroughi et al, 2011 [25]	Women > 40 with primary OA in at least one knee	54 F	RCT	6 months	Six months of high-intensity progressive resistance vs. low-resistance exercise (sham regimen).	There was no difference in the first peak knee or hip adduction moment ($P > 0.413$). The second peak adduction moment was reduced significantly ($P = 0.025$), as well as WOMAC pain score ($P < 0.001$) in both groups.
Jan et al, 2008 [22]	> 50 years old with confirmed OA	79 F, 19 M	RCT	8 weeks	Eight weeks of high-resistance (HR) or low-resistance (LR) exercise or no exercise (control).	There was statistically significant reduction in pain and improvement in function in patients who were in high-resistance and low-resistance cohorts. There was no significant difference between the high and low resistance cohorts.
Mangione et al, 1999 [23]	Community dwelling ≥ 50 years old with painful OA	26 F, 13 M	RCT	10 weeks	High effort (70% of heart reserve) or low effort (40% of heart reserve) for 10 weeks of stationary cycling.	There was a significant improvement in chair rise time, ($P < 0.001$), 6-min walk ($P < 0.001$), AIMS2 pain score ($P < 0.001$), and Aerobic capacity GXT time ($P < 0.001$) from pre-intervention to post-intervention in both cohorts.
McCarthy et al, 2004 [26]	> 50 years old meeting the ACR's classification of OA	125 F, 89 M	RCT	1 year	Home exercises only or home exercises with addition of 8 weeks of twice-weekly knee classes run by a physiotherapist.	There was significant improvement for the class-based group in locomotor function (-2.9 s; 95% CI: -4.0 to -1.8) and walking pain (-14.9 mm; 95% CI: -18.1 to -11.7) compared to home-based group.
Ng et al, 2010 [24]	40 - 75 years old with hip or knee OA	17 F, 11 M	RCT	24 weeks	High-intensity (walk 5 days/week) or low-intensity (walk 3 days/week). Up to 3,000 steps/day for first 6 weeks, up to 6,000 steps/day for the next 6 weeks. Final 6 weeks, exercise program of patient's choice. Eighteen weeks of glucosamine (GS) intake (1,500 mg/day) started 6 weeks before walking regimens. Patients could choose to stop GS in the final 6 weeks (weeks 18 - 24).	GS only period led to improvements in activity levels, physical function and WOMAC scores ($P < 0.05$). Further improvement seen in these outcomes after walking regimen started ($P < 0.05$). No difference between high intensity and low intensity groups.
McAlindon et al, 1999 [21]	Framingham heart study patients with radiographic normal knees at baseline	470	Cohort	8 years (Biennial exam 18 - exam 22)	Patients with normal knees on radiograph at exam 18 received follow-up radiographs on exam 22 to assess for radiographic OA or symptomatic OA.	Heavy physical activity increases incidence of radiographic OA (OR = 1.3/h; $P = 0.006$). The risk was even greater for obese individuals (OR = 13.0). Similar results for symptomatic OA, but not significant due to small number of cases.
Felson et al, 2007 [19]	Framingham heart study	1,279	Cohort	9 years	Patients without OA at baseline were surveyed on pain and physical activity, and had knee radiographs performed. Nine years later, they were assessed for radiographic OA, symptomatic OA, and joint space loss.	In middle-aged and elderly without knee OA, recreational exercise did not protect against or increase the risk of OA regardless of BMI.
Plotnikoff et al, 2015 [18]	Non-institutionalized individuals ≥ 18 years	1,808	Cross-sectional	No follow-up	Phase 1 consisted of a phone interview. Phase 2 included clinical measurements and additional self-reported health information.	In a logistic regression model, physical activity was not associated with OA prevalence. Being obese was strongly associated with knee and hip OA prevalence (OR: 4.37 and 2.52).

walk test (P < 0.000), pain score (P < 0.000), range of walking speed (slow walking P < 0.01; fast walking P < 0.00), and aerobic capacity (P < 0.000). No meaningful difference was found between the two groups in any outcome.

Similarly, Ng et al [24] performed an RCT in which 28 subjects with hip or knee OA were placed into a high-intensity (5 day/week) or low-intensity (3 day/week) exercise regimen and all subjects were given glucosamine sulfate (GS). For the first 6 weeks, they only took GS followed by 6 weeks of up to 3,000 steps/day, 6 weeks of up to 6,000 steps/day and finally 6 weeks of an exercise regimen of their choosing. It was the patient's choice to continue taking GS in the final 6 weeks. The results of the study revealed no significant difference between the two groups and the data were combined and analyzed further. After 6 weeks (GS only), there was meaningful improvement in the self-paced step test (SPS) (P < 0.05), stiffness (P < 0.05) and function (P < 0.05). However, the authors note that the subjects increased their physical activity (P < 0.05) when advised not to do so. From week 6 to 24, there was significant gains made in amount of exercise (P < 0.001), SPS (P < 0.001), pain (P = 0.01), and function (P < 0.001), suggesting that the increase in physical activity may have led to improvements in SOA.

A single-blinded RCT was conducted by Furoughi et al [25] to evaluate the effect that lower extremity muscle strengthening has on knee and hip adduction moments in 45 women with confirmed knee OA. The authors found no significant difference between the high-intensity and sham group regarding the primary outcomes of knee and hip adduction (P > 0.413). Both groups had significant reductions in the secondary outcomes of second peak hip adduction moment (P = 0.025) and Western Ontario and McMaster's Universities OA index (WOMAC) pain scores (P < 0.001), suggesting a benefit in patients with SOA. In a similar RCT, McCarthy et al [26] included 214 patients with knee OA, to investigate if a home-based exercise program supplemented with a twice per week physiotherapist led class would affect locomotor activities, pain and disability. The authors found that the group that attended the additional class had significant improvements over the group who did not attend the class. Locomotor function increased 12% (-2.9 s; 95% CI: -1.8 to -4.0) and walking pain decreased 27% (14 mm; 95% CI: -11.7 to -18.1) for the supplemented group. Also, this group experienced meaningful improvements in balance, strength and WOMAC score (P < 0.05).

In a prospective study that included 100 patients with denuded areas of subchondral bone (dABs) at the central weight-bearing medial femur (cMF), Kwee et al [27] used an MRI to assess the relationship between physical activity and progression of cartilage loss within the medial tibiofemoral compartment (MTFC) at 2-year follow-up. Using the physical activity scale for the elderly (PASE), there was no significant relationship detected between the physical activity levels and knee cartilage loss. The authors note that the study may have been underpowered to detect slight variations in cartilage loss.

In summary, the five studies describing physical activity in patients who have OA all demonstrated improvements in SOA. The level of physical activity (high versus low intensity), however, did not show differences between one another. There were only differences when either of the activity levels was compared to no activity at all. The one study describing radiographic outcomes did not show progression of OA with activity.

Conclusion

Increased physical activity level and exercise as well as decreased leisure time, show a consistent benefit in the prevention of cardiovascular disease and mortality [9-15]. An increased amount of time that is spent being sedentary also shows a significant correlation to cardiovascular disease [10, 11, 13, 15-17], even with regular exercise [13]. Overall, time being physically active appears to be the most important influence on the reduction of cardiovascular disease risk. There is a lack of evidence to show if intensity of exercise plays a role.

While one study correlated heavy physical activity with increased rates of ROA [21], three other studies failed to show any association between physical activity levels and OA development [18-20]. Even though running can be viewed as a high-impact exercise, it was not shown to have any impact on the development of OA [20]. Physical activity was shown to reduce symptoms in patients with confirmed OA [22-27].

Physical activity may decrease cardiovascular disease and improve OA symptoms, and therefore, motion can be considered a "medicine". However, because heavy activity can potentially lead to increased OA risk, physicians should advise their patients that excessive activity can also potentially impact their health negatively, and should be done in moderation, until further study, for prevention and treatment of cardiovascular and musculoskeletal diseases. Future studies need to assess this more carefully. Specifically, studies need to better define and standardize different levels of physical activity, and assess their impact on cardiovascular and musculoskeletal health. Cohorts that should be assessed include both patients with and without baseline vasculopathic disease and OA. Additionally, because both cardiovascular and musculoskeletal diseases are tied to obesity, future studies should assess effects of varying levels of weight on these outcomes. This should also be studied in the context of diet, as it is well known to be linked to obesity.

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