Exercises Pursued by Older Adults with Osteoarthritis and Their Structural Impacts are Hard to Uncover; a Scoping Review of Selected 1970-2024 Studies

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Abstract

Persons with osteoarthritis often have signs of reduced muscle strength. Some studies suggest that this strength could be improved with exercise. However, does this form of therapy improve the disease status as assessed by improvements in cartilage viability, a hallmark of the disease? This brief describes the possible usage of exercises in general, plus those known to improve strength and function, and reduce pain and whether structural impacts that favor or impede disease regression have been observed in this context among the older osteoarthritis adult population. Since exercise may also do harm, rather than good in osteoarthritis management if excessive, contra indicated, or suboptimal, what is the consensus in this regard in 2024?

Introduction

Osteoarthritis, the most common rheumatic disease is a chronic condition affecting the majority of the older population. Commonly deemed incurable, osteoarthritis is a well documented and frequent source of functional disability and pain despite years of research and intervention attempts. In the context of the increasing aging populations worldwide, the collective costs of the disease, considered as a key determinant of an age related intrinsic capacity decline [1] are enormous. Unfortunately, its prevalence appears to be increasing [2] and increasing at an alarming rate [3].

Commonly characterized by progressive bone remodeling, bony outgrowths, and micro fractures, cartilage tissue fragmentation and degeneration, plus possible joint capsular fibrosis, ligament instability, muscle pathology, and often joint derangement and instability, osteoarthritis joints may become poorly aligned and more susceptible to cumulative or sudden joint impact forces with dire functional consequences [4]. In addition, muscles surrounding the affected joint may not only become weaker than desirable, but respond more slowly than desirable, and may thus be less able to absorb joint impact effectively. Adding to the disease burden may be ensuing bouts of accompanying joint inflammation and pain, muscle fat infiltration, decreased range of joint motion, impaired muscle reflex responses, subnormal proprioception, adverse emotional reactions, and joint deformity.

On the premise that exercise will delay muscle atrophy [5] or provide increased joint stability [6], persons with osteoarthritis are frequently encouraged to undertake exercise. While exercise can objectively improve physical performance with no documented detrimental effect [7], and may even have beneficial effects on type II collagen metabolism, especially in people without radiological osteoarthritis [8], the effects of exercise training for persons with osteoarthritis as regards its structural features and loading impacts either favorable or not have not been thoroughly examined and cannot be deduced from preclinical models or those carried out by healthy persons or persons with osteoarthritis who undergo exercise but have no radiologic measures either at baseline or after 6 weeks [9] or 12 weeks of intervention [10]. Variance due to age and disease manifestations, mode of exercise [11-13], methodological limitation in exercise protocol reporting [14] as well as exercise duration [15], frequency and dosage, the role of allied therapies [16], and exercise adherence rates are also influential factors not well articulated in randomized controlled studies and others [17-19] and cannot explain either exercise associated successes or lack of success.

Based on a sample of parallel reports it can argued that exercising can place widely varying biomechanical and physiologic demands upon the cartilage tissues and its cells and fibrous supportive surrounding matrix that may or may not stimulate cellular biosynthesis, which is the basis for the adaptation and viability of this important joint shock absorbing tissue lining [20-22]. Moreover, in some studies it could be shown that joint motion without compression could cause articular cartilage thinning, while static loading caused a decrease in chondrocyte biosynthesis. It was concluded that there may be cartilage activity thresholds below and above which the effects are minimal or destructive, as opposed to beneficial. Because the adaptive capacity of articular cartilage may be compromised in the injured, overloaded, or aged joint [23] that is heightened in the presence of lower than desirable muscle mass [24], and measures of cartilage using ultrasound produced differing results across differing exercise modes [25], it seems reasonable to examine if those recommended exercises to counter osteoarthritis are equally ‘good’ for all or need to be carefully designed, titrated and implemented with care in the older adult with compromised joint and muscle health until more is known even if somewhat refuted by Marriot et al. [26].

However, in addition to observations that support modest exercise as a beneficial cartilage mediating strategy, that observed in light of the above mentioned potential research limitations, plus those denoting no adverse or favorable cartilage based impact in the context of a single exercise bout in severely damaged knees prior to surgery [27] cannot be generalized to any meaningful degree. Similarly, data extracted from healthy cartilage assays designed to discern exercise metabolic effects [28], plus those gleaned in the realm of various running related studies [29], secondary analyses [30] or the post traumatic osteoarthritis rat model must be viewed with caution [31] despite a global consensus on applying exercise as a front line strategy for improving osteoarthritis status.

Aim

This present overview aimed to examine whether exercise as applied to osteoarthritis has any impact on cartilage tissue assessed directly through radiographs, the gold standard measure in this respect. As well, resistance training in the form of isometric exercise, one of the oldest forms of exercise used for arthritis management was specifically examined and if so what radiological or its proxy measures as assessed through serum measures, biomechanical, or force measures indicate in this realm and in what regard.

Research Question

The review attempted to establish whether exercises that have been studied for many decades appear to reduce joint attrition and its progression objectively, while increasing increase muscle power and function safely and significantly in osteoarthritis contexts.

Rationale

In light of the continued osteoarthritis disease burden that is increasing rather than decreasing, along with the current emphasis on applying evidence based medical recommendations in all spheres of endeavor, versus hearsay or traditional approaches, it appears reasonable to ask if the lack of solid evidence that exercises can be applied successfully without any discrimination or on the basis of the prevailing studies to improve osteoarthritis wellbeing is based on sound science and/or takes into account its variable pathology, sub groupings, and characteristic features of osteoarthritic joint change. These features include: progressive bone and articular cartilage degenerative changes, capsular fibrosis, ligamentous damage, joint laxity, sensory (mechanoreceptor) receptor changes and extensive muscle pathology. Joint inflammation is also a consistent feature of along with pain, joint effusion, stiffness, decreased range of joint motion, muscle weakness, joint instability and deformity, and progressive reductions in the efficiency of musculoskeletal functioning. But, the question arises as to whether as applied to the older adult population, whether exercise is a panacea or can a failure to act cautiously in exercise applications in the presence of osteoarthritis induce more rather than less disability and adverse psychosocial reactions and thus more costly outcomes [32].

As well, since even modest stretching exercises may prove injurious, for example in cases that are neuropathic [33], is the blanket conclusion that osteoarthritis cases will demonstrate flexibility improvements with physical exercise participation [34] adequate for ensuring optimal benefits for all, for example in cases with joint instability? Similarly, is the idea of exercising to tolerance sufficient to achieve desired results if this protective neural sense or reflex response is subnormal [35] or the diseased limb is poorly aligned [36]. Moreover, should caution be taken to address possible adverse exercise impacts that may damage cartilage, while trying to promote more optimal functional and loading outcomes or regenerative processes [3].

Significance

The question of whether exercise has a uniformly beneficial impact on an osteoarthritis joint in the older population is topic that warrants more scrutiny in our view because even though multiple affirmative studies imply a significant pain relieving benefit, surgery continues to be demanded by those who may have pursued exercise diligently. This may be because muscles and their physiological and structural attributes may be dysfunctional to a considerable degree in a high percentage of osteoarthritis subjects and thus benefits from exercise applications may not align with those observed in the lab. Moreover, exercise that is poorly designed or supervised [37] as well as poorly targeted and titrated may fail to improve joint status uniformly or even worse, may do more harm than good [20], for example in those with more severe rather than less severe cartilage damage [38]. Indeed, exercise that is simply employed for all cases equally, even though intuitively these may not impact differing cartilage lesion sites equally or favorably and may not be helpful for attenuating the chronic susceptibility of osteoarthritis cartilage to mechanical impacts in all cases [27] may prove highly undesirable, even if promising for cases apparently at risk for osteoarthritis [37]. As well, for similar reasons are programs of unsupervised, partially supervised, or remotely delivered internet based exercise protocols likely to prove universally efficacious or replicable in light of the challenges faced by an older adult in pain with limited function and possible depressive symptoms, low health literacy and resource access, and especially in view of the possible degree of cartilage damage that could be generated by exercising to fatigue or in the face of ligament laxity [20, 39, 40] or muscle pathology or both.

Methods

A comprehensive overview of peer reviewed publications posted on **PUBMED, Google Scholar**, and **PubMed Central** in any year was conducted to address the present article aims. Among these data were 9397 articles posted as of August 25, 2024 on **PUBMED** using the key words '*osteoarthritis and exercise*', the total number of posted unfiltered resources numbered 9417, 160 were meta analyses, and 8718 were available in full text, but only 4763 were available on line. A total of 8922 of which 4356 were available in full text online referred to *isometric* exercise, of which 1409 were randomized trial reports dating back to 1982 with 1134/1409 randomized trials of isometric exercise related articles focusing largely on knee osteoarthritis. Very few studies examined exercise and cartilage repair associations if any, even though this may prove of high clinical relevance as well as highly insightful.

Considering the plethora of exercise associated studies cited on the three data bases currently examined, and the mostly mixed samples, study designs, and modes of treatment but few analogous or replication studies or consistent themes of exploration, we elected to focus on examining both exercise impacts in general as well as resistive modes, as observed in randomized controlled trails, and often advocated for treating arthritic joints because they involve muscle contraction without producing joint motion, and in the belief that transarticular forces can be duly minimized as result. Brown et al. [41] have also suggested that this form of exercise may prove more suitable than dynamic exercises for persons with osteoarthritis that may be more painful especially in cases with inflamed unstable osteoarthritis joints. They may also foster overall cardiovascular health, bone health, psychological health, and aid in obesity prevention [4], muscle and neural protective mechanisms that may fail in osteoarthritis [42, 43] or provide increased joint stability [44] often associated with the presence of joint degeneration. We excluded preclinical or animal based exercise or simulated osteoarthritis studies, studies focusing on osteoarthritis cases younger than 60 years of age, foreign language studies, physical activity, passive motion, internet delivered, and balance oriented exercise related studies, joint replacement surgery associated studies, muscle stimulation and platelet rich plasma studies, study proposals, and other data bases such as EMBASE, CINAHL, and Science Direct. Only a qualitative scoping overview is provided, no subgroup studies are included unless exercise associated, and readers can refer to referenced meta-analyses for further in depth assessments [see selected references 45-50].

Current Findings

Even when earnestly sought, and regardless of data base employed, it was unusually challenging to delineate or even uncover the potential impact of formal exercise in any form on osteoarthritis associated joint structures of any sort, and what actual post exercise functional results were observed. Almost none assessed any probable joint soft or hard tissue impacts or status directly or even indirectly, and in those studies using multiple intervention formats results could not be attributed to exercise per se in many cases with any degree of certainty. Moreover, rather than testing the most widely employed and recommended forms of exercise for arthritis, most current studies failed to apply isometric exercise methods of various doses and combinations and were not those that could be readily subsumed by most older adults, such as eccentric high intensity exercises.

As well, there was little evidence regimens studied were applied with the goal of maximizing one or more outcomes based on the specificity of exercise theory, wherein exercise has both general, as well as specific effects on muscle that can be optimized. By employing vastly differing subject groups with varied degrees of osteoarthritis, where most over age 80 were not included in the study, as well as largely subjective measures, and few objective outcome assessments, loading estimations, biochemical, neuromotor, kinematic, and radiographic baseline and outcome measures, with few exceptions [eg.,51-54] it is impossible to state that exercise is universally beneficial and its effects are similar no matter how these are applied. In addition, among the many research reports reviewed, most pertaining to exercise focused on the knee joint, with few exceptions. Even in this case, where the consensus remains that pain and function improve no matter how exercise is practiced or how often [47, 55-57], with few exceptions [46], not all exercise participants are found to improve, but why this is, is largely unexplored.

Since osteoarthritis is a complex disease with many overlapping features, the assumption that all exercises are equal in impact as well as beneficial or safe in all forms and stages of this disease must be questioned given most researchers failed to confirm the presence or absence of any accompanying joint loading improvements or non improvements or worsening of joint structural stability plus inflammation, and disease biomarker status. The associated relevance of extraneous variables such as obesity, muscle metabolic and structural post exercise alterations [57-59], plus the probable mediating role of comorbidities, stress [59] and possible age related intrinsic capacity declines [1] are also hard to discern at present. Adherence as well as to what degree home exercises performed in some studies replicated the desired recommendations with high fidelity is also not duly reported or evident in many cases or negated as a factor of note [57]. Moreover, even if exercise appears 'no better' than placebo [30], the consensus that exercise participation reduces osteoarthritis pain, and improves function in the short term should be qualified more acutely. In addition, even if this is a universal finding given that there may be limitations to the extent to which pain can be attenuated in some cases a patient should have an accurate idea of what to expect. In addition to those items mentioned above, it is not clear if exercises applied in the face of any undetected probable muscle or joint sensory disturbance and movement abnormalities anticipated in the older adult will limit gains in function or not or whether more pathology than desirable might ensue. The role of medications to counter pain is also not well controlled for and without patient education, those who do sustain pain relief may tend to function in ways that heighten joint impact inadvertently or fail to protect joints against muscle fatigue.

At the same time, even if deemed high quality as far as research design goes [56] not all published exercise regimen data may apply to all older osteoarthritis cases especially those with some form of heart disease for example who may not be studied, or where no adaptations to the studied regimen are evident or alluded to, as well as those with one or more co morbid health conditions.

Moreover, in accepting that more cases performing exercise will have less osteoarthritis pain than not, no matter how this is approached [26, 57], the data fail to clearly support this premise for large samples, or for example for hip osteoarthritis [30] or as mentioned by Hinman et al [59] where the role of extraneous variables, competing interventions, and reasons why some exercise participants do not respond favorably in all cases is often unreported, while blinding and instrument subjectivity, and reliability and fidelity of these are not always assured or discussed and where exercises may be unsupervised, applied on a limited basis, and based on complex exercise combinations [30, 60] or possible practitioner as well as patient personal preferences. Safety issues due to poorly directed and enacted exercise impacts in the face of joint damage and derangement, in particular, for example in the frail older adult with sarcopenia or bone fragility are unfortunately rarely alluded to.

Unsurprisingly, even in the realm of some key resistance or alternate exercise modes applied in a controlled manner, results remain challenging to aggregate, hard to validate, and apply with any degree of certainty. Not only do exercise approaches differ considerably, but whether these result in disease modifications that are measurable objectively, and that could help identify salient underlying explanatory and disease mediating mechanistic processes, for example the observed lack of exercise impacts on the osteoarthritis knee adduction [61] or frontal plane moments [62] and other outcomes as consistently evidenced in this body of data [See snapshot Table 1].

In addition to the snapshot above, and even when considering all currently published exercise oriented osteoarthritis meta-analyses and research studies of note it appears that despite years of endeavor no single form of exercise is found to consistently produce a pain free result for all osteoarthritis cases or appears to be of the highest merit overall. Additionally, even if sample sizes that are modest at best are discounted as non representative of the population, and very few attempts at sub group assessments are evidenced to date, why some cases respond favorably or unfavorably to exercises in general, as well as specific modes of exercise in this regard [5, 55], why some cases with osteoarthritis adhere or do not adhere to exercise recommendations [64] and why exercise does not improve depression attributes [45] even if it relieves pain - but not in all cases [74], remains hard to uncover. Even if this set of findings is affected by the application of diverse albeit limited subjective survey questions, the role of the halo effect, patient and provider perceptions, unknown reliability of measures, patient health literacy and memory challenges, lack of exercise specificity, or reflex muscle inhibition, it is impossible to deduce their individual or collective importance when considering exercise applications for older osteoarthritis cases at present. Pain too is commonly assessed using differing instruments and possible definitions and modes of expression with no parallel time based objectively derived and clinically relevant associated disease indicators, thus even here a strong basis for any form of exercise as the active variable in pain reduction is challenging to support.

At the same time, outcome indicators that might reflect the disease characteristics more closely than not are often not detailed. These might include, but should not be limited to factors such as:

Table 1. Sample of Selected Resistive Exercise Intervention Studies and Others and Impacts as Applied in Randomized Trials for Knee Osteoarthritis Showing Some Benefits, but _few_ Radiographic or Cartilage Composition and Loading Biomarker Assays and Impacts

GROUP	METHODS	CLINICAL FINDINGS	CARTILAGE ASSAY
Baker et al. [63]	*4m High Intensity Home Based Progressive Strength Training vs Nutrition (n=46 cases > 55 yrs)*	+ improved pain, function, strength, life quality	x
Bruce-Brand et al. [64]	*6 wk Home Based Resistance vs Neuromuscular Stimulation vs Controls (n=41, ages 55-75)*	+ equal functional benefits, cross sectional area muscle/ strength	x
De Zwart et al. [65]	*12 wk High vs Low Intensity Resistive Exercises + Vitamin D (n=177, mean age 67 yrs)*	+ pain, function, mostly equal results	x
De Vita et al. [66]	*Quadriceps Strength Training (n=30)*	+ strength/pain, no biomechanical effect	x
Holm et al. [67]	*12 wk Neuromuscular/ Strength Training (n=64)*	+ strength, function	x
Huang et al. [68]	*12 wk Knee Extensor Strengthening (n-58)*	+ pain, function	x
Messier et al. [69]	*High vs Low Intensity Training (n=377, > 50yr)*	- pain, function, joint status equal	x
Kus et al. [55]	*Sensory Motor/Resistance Training (n=48)*	+ pain, function, equally	x
Oğuz et al. [70]	*6 wk Exercise/Exercise and Taping (n=22)*	+ pain, function, equally - cartilage metabolisms changes	Y
Øiestad et al. [71]	*12 wk Strength/Aerobic Training (n=168, ages 35-70 yr)*	+ muscle strength, VO2 max - no quality of life benefit compared to standard care	x
Onwunzo et al. [9]	*Isometric Quadriceps and Straight Leg Raise Exercises (n=40; mean age 58 yrs)*	+ pain intensity, range of motion, functional ability	x
Vincent et al. [72]	4 m *Concentric vs Eccentric Training (n =90, ages 60-85 yr)*	+ pain, function equally	x
Yabroudi et al. [73]	*24 Sessions Resistance Exercise vs Pulsed Electromagnetic Fields (N=34)*	+ pain and function improved equally	x

Abbreviations: + improved; - not improved/altered; m=months; wk: weeks; yr(s)=year(s)

a. the degree of joint effusion,

b. joint range of motion,

c. muscle fiber size and composition,

d. muscle recruitment patterns,

e. inflammatory biomarkers,

f. body mass,

g. functional kinetic and cognitive features,

h. actively assessed aerobic capacity.

Additionally, attempts to overcome the presently vastly differing intervention frequency, duration, and intensity approaches to exercise that exist along with limited follow-up accounts of their impacts on key structural joint features and others are hard to generalize [7, 75]. How cases with poor health status, those who suffer from obesity as well as those who are frail physically or emotionally respond to exercise of any mode is not clear as well even if selected survey data indicate post exercise functional gains as a common observation [30, 49].

In sum, despite the goals of most clinicians – what should be done or undone or avoided when assessing a specific client's exercise needs cannot be discerned with any degree of predictability as beneficial or optimally beneficial and safe or appropriate for achieving a set of desired outcomes [49] in light of any patient related exercise preferences [76-78]. Moreover, how exercise will impact a vulnerable joint is a complex event determined by (1) the nature of the applied load, (2) the load distribution within the joint during the specific activity and (3) the mechanical properties of the cartilage [21]. Thus despite possible favorable exercise induced reductions in pain, cartilage impacts may not be assumed appropriate, especially if pain is relived and high impacts or excessive compression inducing or fatiguing exercises are carried out by those who are not mindful of joint injury, or who undertake sub-optimal or non specific joint exercise regimens [10]. A further unknown is the probable role of suboptimal loading movements on vulnerable joints as well as the disease progression and its spread to other joints that may be perpetuated or magnified even if surgery is forthcoming [79].

To advance this line of inquiry where systematic reviews do not always concur or fail to assimilate comparable data, we propose that dedicated study is warranted here so as to protect the vulnerable older adult with osteoarthritis from a low life quality as well as from probable increasingly adverse cartilage tissue and joint impacts as based on animal models subject to subnormal joint loads. Applying similar methods to those used in the lab including more careful study selection criteria and controls plus advanced clinical and biological as well as imaging data over time relative to baseline and patient characteristics would appear to hold great promise. In particular, as attempted by Lange [4], radiographic measures applied in a standardized manner to exercise and comparable non exercise groups [58] exposed to different modes of exercise training [80] among cases with varying degrees of muscle pathology are likely to be beneficial and insightful. A concerted global effort to obtain data on various exercise applications on joint inflammation and effusion, joint stability and alignment as well as serum disease biomarker levels, muscle composition and kinetic measures over an extended time frame could prove highly revealing as well, even if not duly mentioned in the past year to any degree [2].

As well, since most older adults diagnosed as having osteoarthritis will likely differ in multiple respects [81], and not all forms of exercise may yield comparable pain and functional impacts as observed by De Zwart et al. [65] and Pazit et al. [82], the role of careful clinical and mechanical evaluation and extending study inclusion criteria to reflect that of older adults becomes even more salient to contemplate in our view. If these exercise modes currently espoused to have similar impacts are in fact not all comparable when viewed as a whole, is tailoring exercise as indicated more likely to prove beneficial than generic approaches, especially among those that are directed to adults of high ages [80 years and above] who present with diverse degrees of disability and who may have varying needs and personal goals. Moreover, since those exercise formats tested in young healthy or older healthy adults may not apply to those with differing degrees of joint disease who are older, more focused research on what will be best for an older adult over time is indicated and should be tested against controls who do not differ on unmeasured outcomes and disease determinants or manifestations, or have dissimilar behaviors or disease attributes. Additionally, the importance of controlling for the behaviors and exposures of non treatment subjects in pilot as well as larger studies plus the impact of attention, concurrent therapies, history, and maturation effects is rarely assessed and identified. For example, those due to media messaging and where control as well as experimental subjects may adopt alternate or additional pain relieving remedies during a trial and this information should be collected at baseline and follow up. Alternately, why post exercise functional benefits may not occur, and if this is due to non adherence versus adverse alterations in cartilage based factors, which is rarely discussed or measured should be assessed to help provide insight in this regard. Why exercise impacts on cartilage – when measured - are not consistently located throughout the tissue, and why joint loading may be either unaffected by exercise [53] or not the same as another [eg., 53, 80, 83] or the same [10] is impossible in our view to discriminate [84] and cannot be inferred by any overall support that favors exercise adoption of any mode for people with osteoarthritis as far as pain and function is concerned in 2024 where few objective assessments prevail.

Even if exercise is underrated, without adequately supportive robust definitive data, the belief osteoarthritis is not curable and movement participation has no effect or can in fact worsen its presence may persist. Either way, patients may either avoid exercise or try to adopt regimens that may place undue loads on their already fragile joints and cartilage matrices, such as running or yoga or those widely touted without any validated evidence by the media, those who 'sell' exercise equipment or gym memberships, and science based public health preventive messages that may not be evidence based or easily performed in the home environment or nursing home, such as aerobic aquatic or resistance exercises in a pool [53] or multi pronged motor learning combined exercise regimens [30]. In addition, even if 'exercise' as a whole appears to have no cartilage based measureable adverse effects [75], this has not been tested in the older adult to any degree, and for any duration, and may yet present a lost opportunity. The lack of any definite exercise oriented data as far as this impacts joint biomechanics [66] may also remain a concern to the older patient who seeks such information along with the careful clinician, for example one who advocates hip strengthening for knee osteoarthritis, but is not sure why it appears efficacious [98]. This scenario may be especially compounded in the instance where very little is known about the impact of various exercises on joint health in the presence of obesity or frailty or joint instability, limited joint range of motion, bone spurs, soft tissue decrements, hyper mobility, osteoporosis, neuropathy, inflammation, cardiovascular conditions, or joint malalignment. Funders and some clinicians who are unaware of the gaps in knowledge may yet align their budgets or recommendations accordingly, and fail to pursue in depth analyses based on the view that patients can simply exercise their way to a better life, and are encouraged to keep an open mind in light of the increasing- rather than decreasing- osteoarthritis prevalence rates among the older population and possible publication bias and areas of import that are under researched [85].

Discussion

Although osteoarthritis has been studied for more than a century, the disease appears to be more common today than ever, and remains the leading disabler of older adults. Often denoted as a disease of the articular cartilage, the tissue lining the ends of bones of freely moving joints such as the knee, this report sought to evaluate the known effects of exercise-almost universally recommended for osteoarthritis care, on measures of cartilage structure that represent the state of attrition or degradation. Exercise was analyzed because it is widely touted as being of value to the patient, and where sedentary behaviors plus muscle weakness may impair overall function and induce inflammation, dysfunction, and pain. Based largely on animal models of osteoarthritis such as the rat exposed to various exercises in those with artificial arthritis [48], it has been proposed exercise adoption will prove beneficial to joint integrity and reduce pain as opposed to a failure to exercise.

Based on the functional requirements of persons with osteoarthritis, as well as the limitations imposed by their joint pathology, it explored if exercises safely improve function and reduce pain in all osteoarthritis cases, and the degree to which this approach can impact its articular cartilage structural features favorably.

Although delimited to: studies of osteoarthritis in the older population this review reveals that despite widespread generic calls across the globe for exercise training and participation for fostering the health of older adults ideally including a combination of aerobic, muscle strengthening, and flexibility exercises for the older or aging adult, this approach may be ill considered for ameliorating cartilage attrition in the sedentary older adult with severely painful osteoarthritis, even if strongly recommended by osteoarthritis experts and others [26, 85]. Commonly recommended regardless of their degree of pathology and/or numbers and extent of any diseased joint, or concurrent comorbidities-often patients who are excluded from exercise studies [eg., 64), most exercise intervention studies used limited variations of subjective measurement approaches, did not focus on disease markers to solidify their conclusions [86] or mechanisms for explaining exercise effects on pain and function [10, 67, 87] or function in one domain but not another [35, 58, 67, 86] even if we did not include all relevant articles.

At the same time although we did review the most extensive medical data sources and those housing meta analyses and conclusions reached by leading reviewers, the body of related meta or umbrella exercise training analyses may not be robust in all respects, nor comparable. They may not for example, provide clear data on adherence issues [eg., 64], nor possible timely data as most reviewed studies were conducted in eras where obesity was not rife [eg., 24] using secondary data sets applied in a single location, and where data collected was largely subjectively assessed [9], and with no baseline osteoarthritis radiographic measure [24, 36]. The lack of inclusivity of the older adult, and the fact the bulk of studies were conducted in funded labs on populations that may not represent those older adults who have no provider, no transport, or insurance coverage or were too impaired to participate or who drop out of programs involving exercise and were not duly followed up.

Why one type of exercise is chosen and not another and how one form of exercise impacts osteoarthritis joints other than the knee or explains non uniform as well as uniform outcomes in varied osteoarthritis studies is consequently very hard to unravel [32]. Moreover, untested older adults with osteoarthritis who are often excluded from studies, may not respond in the same way as younger adults to exercises and those that are remotely offered may not yield the same outcomes as carefully supervised exercises. Assuming older adults in pain will readily follow exercise if deemed helpful as a health strategy [10, 67, 88, 89], carrying this activity out over time may prove challenging for those in poor health as well as those with multiple physical challenges, plus possible bone, soft tissue, sensory declines, poor endurance, and inflammatory provoking micro impact injuries [64].

In addition, exercise carried out in the absence of patient education [95] may not prove efficacious if it induces excess or non physiological impacts on the diseased tissue [8, 24] even if pain appears to be reduced in various controlled studies [3]. What is meant by moderate exercise and evidence for having a 'null' effect in osteoarthritis cases even if advocated [90] must remain in question especially where data are deemed to be generated from lower than desirable quality research [91] and acute exercise effects in young adults [32], or on non radiographic assays and not any other [92].

Indeed, perhaps older adults with osteoarthritis are suffering in excess because even with over 100 exercise based therapy studies espouse benefits on pain and function, they still fail to provide indisputable evidence that pain relief in osteoarthritis and exercise are robustly linked [76] and its multi layered and complex presentation in the older adult in this regard is rarely measured or discussed.

Rather, there is an assumption of a 'one size fits all' osteoarthritis diagnoses, and that its association with exercise is a linear and a universally conclusively favorable one [93] and can be applied based on patient or doctor appraised preferences [96] despite recognition of its somewhat unpredictable site specific joint loading responses that needs to be acknowledged [99]. As well, since cartilage is exquisitely sensitive to excess mechanical or suboptimal loading impacts [94], rather than being a passive tissue, it may require sufficient post exercise or intermittent programmatic rest periods to avoid negative deformation associated cartilage load effects as found in healthy young adult men immediately post exercise that could impact metabolic and remodeling processes [97]. Alternately, the impact of both appropriate as well as possible poorly selected and implemented exercise modes on damaged cartilage as well as end stage joint degeneration cannot be readily predicted or extrapolated from such studies and needs more thorough investigation in its own right as intimated by Thudium et al. [40]. This group found cartilage tissue turnover and cartilage degradation appear to increase in response to a 3-month exercise-related joint loading training program and at 6-month follow-up, with no evident difference in type II collagen formation. Aggrecan remodeling increased more with high-intensity resistance training than with low-intensity exercise. These exploratory biomarker results, indicating more cartilage degeneration in the high-intensity group, in combination with no clinical outcome differences of the VIDEX study, may well argue against high-intensity training even if well tolerated.

In the interim, function, functional performance and life quality as well as research quality in exercise based assays remain questionable at best despite numerous study attempts [78, 100, 101]. In addition, while deemed safe no matter what mode of exercise is adopted, this cannot be validated readily for older adults and on the basis of structural joint features as well as functions of daily living and for joints other than the knee. This situation and the relevance presently highlighted, plus knowledge gaps and finding inconsistencies surely needs to be addressed promptly in multiple spheres in our view so as to not only eliminate discordant findings, but to help clinicians to better tailor their recommendations and avert modes of high impact exercise that could prove injurious. Research needs to better elaborate on how older adults living in the community safely can confidently pursue exercise recommendations without undue human and other health or societal resource demands and that can be performed regularly at low cost and without stress and fatigue effects.

Alternately, the costs of failing to do this can be expected to rise in multiple ways and especially if exercise impacts on function and life quality cannot be validated and exercise dosages applied that do have a bearing on osteoarthritis pathology remain unknown. In addition costs will rise if for example, only a small number of cases over time appear to do better than those who receive no treatment, or where treatment or its impact is suboptimal, ineffective, or possibly harmful or determined by type or groupings of osteoarthritis [101-110]. As well, if the potential for or limits of averting excess cartilage load, or more importantly enhancing cartilage reparative processes remain unknown, even the best efforts to maximize life quality and mobility options may prove unsuccessful, as well as possibly inducing or encouraging excess drug or costly invasive treatments or both. The fully fledged understanding of recorded post exercise adverse events as well as benefits remains unknown at present and may be inducing rather than alleviating suffering.

While no simplistic approach will be enlightening on its own, to make some headway in this complex realm, in tangible ways, perhaps the use of small workshop collectives, single case studies, and careful ‘n of 1’ single subject design efforts or follow ups of current study participants over time, can generate some helpful insights and enlightening data. In addition to careful sample selection, efforts directed towards reducing potential measurement errors, combining animal and human related studies, employing artificial intelligence diagnostic assessments [AI] and others using agreed upon sensitive assays and parameters that allow for advanced statistical analysis of the included demographic, clinical, radiographic, and musculoskeletal profiles are especially recommended.

Implications

To avoid provoking excess or preventable disability and pain and the undue expenditure of energy required by some forms of exercise, and that could reduce overall functional performance capacity, it appears careful evaluation and applications of supervised exercises of modest intensity that are not impactful on the joint[s] of the older adult with osteoarthritis and that builds on what we know can be helpful, and should be based on clinical indicators as well as radiographic, imaging, neuromotor, biomechanical and biochemical measures.

As opposed to a failure to do this, a comprehensive effort at baseline and follow up may make the difference between the immense benefits of ‘precision’ versus ‘generic’ medicine approaches that may not work for all older osteoarthritis cases.

As observed by Kong et al: [48] it appears: 1) exercise recommendations can best be served in the future by clarifying their mechanism of action, their similar and dissimilar effects, and providing or acquiring more certainty about their osteoarthritis associated disease modifying or restorative effects in the context of older adults with varying degrees of disability. 2) It will also help clinicians and researchers if publications are more widely available for patients as well as health workers who are not linked to a well funded university or college publication source. 3) Agencies guiding older adults can help by making all research accessible to them. 4) Primary care physicians and allied health personnel can conduct more regular assessments of the disease status of clients and help assure patients are well educated and have the resources they require to adhere to their recommendations.

Concluding Remarks

- Based on our concerted effort to access and synthesize or uncover any specific trends or clinically relevant observation between exercises and radiological or disease markers in older adult populations with osteoarthritis, what is clear is the absence of such data as well as many less than robust clinical trials on varied rather than a single intervention strategy, thus claims that exercise of any mode is beneficial or harmless cannot be totally justified in our view.

- We further conclude that to foster as well as forge more firm and robust conclusions about the scope of exercise and its bearing on osteoarthritis degradation, experts in the field, clinicians and others should brook no further delay and engage interactively to support multi centric long-term larger studies to examine and validate all the nuances of the phenomenon of supposed disease modifying influences of exercise on articular tissues in both treatment successes as well as failures so as to help identify best evidence based patient directives and the utility of adopting one or more regimens of exercise by older adults with diverse forms of osteoarthritis pathology.
- To this end, we propose more efforts to carefully consider the fact that a one size fits all approach is actually foreign to other medical realms such as heart disease, osteoporosis, stroke, rheumatoid arthritis, and respiratory ailments. Additionally efforts to integrate biomechanical and laboratory measures into the evaluation of osteoarthritis cases before advising them to exercise are strongly indicated.

Final Thoughts

In the face of the mounting older population and their susceptibility to this currently incurable degenerative joint condition termed osteoarthritis, we urge the dedicated researcher and clinician to forge a pathway that can add to and shed light on the existing evidence base upon which family practitioners and others can better rely and act safely and efficaciously using strategies consistently found to be restorative, regenerative, life affirming, or preventive.

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