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Review

Factors associated with physical activity in patients with osteoarthritis of the hip or knee: a systematic review

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SUMMARY

Objective: To give an overview of factors related to the level of physical activity in patients with hip or knee osteoarthritis (OA).
Methods: An extensive systematic literature search was conducted in PubMed, CINAHL and Embase. Inclusion criteria were: studies on patients with a diagnosis of OA of hip and/or knee, studies describing factors related to physical activity (objective or subjective), full length articles that were published in Dutch, German or English language. Two reviewers independently assessed the methodological quality. A best-evidence synthesis was performed for factors which were investigated in two or more studies.
Results: Eight studies were included, all with a cross-sectional design (five high quality and three low quality studies), resulting in, at most, limited evidence in the best-evidence synthesis. For patients with knee OA there is limited evidence that a lower level of physical function is associated with a lower level of physical activity. There is also limited evidence that depression is not associated with the level of physical activity. For patients with hip OA there is limited evidence that higher age, higher body mass index (BMI) and a low level of physical function is associated with a low level of physical activity.
Conclusion: A high age (hip OA), a high BMI (hip OA) and a low level of physical function (both hip and knee OA) are related to a low level of physical activity. However, the level of evidence was only limited. Before new strategies and interventions to increase physical activity in patients with OA can be developed, high quality longitudinal studies are needed to get more insight in the causality between factors and low levels of physical activity.

Introduction

Osteoarthritis (OA) is a chronic degenerative musculoskeletal disorder, which can affect multiple joints in the human body[1]. OA has a high prevalence; in the Netherlands the prevalence of OA of the knee in general practice is for male 14.3/1,000 and female 23.8/1,000. The prevalence of OA of the hip is for male 10.2/1,000 and for female 18.9/1,000[2]. Patients with hip or knee OA often show pain, muscle weakness, limited range of motion, and decreased functional ability of affected joints[3,4]. Furthermore, OA has a major impact on physical functioning in daily life[3–5]. Several risk factors for decline in physical function have been identified, such as pain, proprioceptive inaccuracy, and muscle weakness[6–8]. One of the most prevalent risk factors for function decline (i.e., activities of daily living) decline in patients with hip or knee OA is a lack of regular physical activity[7,8].

The general health benefits of physical activity are well documented. Regular physical activity is, for example, associated with lower prevalence of obesity and many comorbidities including diabetes and cardiovascular disease[9,10]. Among patients with knee OA, physical activity programs are, besides the above mentioned benefits, beneficial for reducing pain and improving physical performance[11]. Despite the potential health benefits of physical activity, the majority of patients with OA are not physically active. Both within the US and Europe, adults with arthritis (including OA) are significantly less likely to meet the recommended levels of physical activity compared to adults without arthritis[12–15]. Next to lifestyle factors, this could also be explained in terms of the avoidance model: some patients with OA tend to avoid physical activity because activity induces pain[16,17]. However, decreased physical activity levels might lead to decreased muscle strength

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and stability of joints, which has been shown to be important risk factors for the onset and the course of OA[6].

Consequently, one of the basic recommendations for the treatment of OA is to increase the level of physical activity. To improve the effects of physical activity interventions more knowledge about the factors influencing the level of physical activity in OA patients is needed. According to Marks *et al.*[18], determinants of adherence to exercises in patients with OA can be divided in three domains, namely individual determinants [e.g., age and body mass index (BMI)], psychological determinants (e.g., the coping style), and illness-related determinants (e.g., pain and functional ability). Until now, an overview of factors, which are associated with the level of physical activity in patients with hip or knee OA is lacking. With such overview physical activity interventions can be improved by including these factors in the intervention (e.g., reduction of pain if pain is a factor related to physical activity). Also, since not all clinicians have insight in the physical activity behaviour of their patients, such an overview can be used to identify patients who are most likely to be physically inactive and may need additional interventions to alter patients' physical activity behaviour. Therefore, the objective of this systematic review is to give an overview of factors, which are associated with physical activity in patients with OA. Separate overviews will be presented for patients with knee OA and patients with hip OA since, for example, the effects of exercise therapy and also the prognostic factors of functional decline are different in patients with knee and hip OA[6,19].

Materials and methods

Literature search

A search of literature was systematically performed in the following databases: PubMed (1966 – January 2011), CINAHL (1982 – January 2011) and Embase (1974 – January 2011). The search strategy was formulated in PubMed and adapted for use in other databases after consultation of an experienced medical librarian. Additionally, reference lists of articles retrieved by the digital search strategy were screened for possible relevant articles. The full search strategy as formulated in PubMed is presented in Appendix 1.

Study selection

Studies were included in the systematic review if they fulfilled the following criteria: (1) Involvement of patients with the diagnosis of OA of hip and/or knee, either according to the American College of Rheumatology (ACR) criteria[20,21] or according to radiological criteria[22]; (2) Studies focussing on factors related with the level of physical activity; (3) Full length articles published in Dutch, German or English language.

Two reviewers (PAH and JAB) independently carried out the whole selection process. Studies were screened upon title, thereafter upon abstract and finally on full text against the mentioned inclusion criteria. In case of disagreement between the two reviewers, a third reviewer (MFP) was consulted.

Assessment of methodological quality

The methodological quality of the studies was independently assessed by two reviewers (PAH and MFP), with the 'Epidemiological Appraisal Instrument – a tool for evaluation of epidemiological studies' (EAI) of Genaidy *et al.*[23]. The types of epidemiological studies that are eligible to evaluate by the EAI include cohort (prospective and retrospective), intervention (randomized and non-randomized), case-control and cross-sectional studies. The EAI proved to be a valid and reliable appraisal instrument that can be used in several applications such as systematic reviews and meta-analyses[23]. It comprises 43 items, of which 27 are applicable to cross-sectional studies. These 27 items are grouped into five sections: (1) reporting (15 items); (2) subject selection (two items); (3) measurement quality (four items); (4) data analysis (four items) and (5) generalization of results (two items). Each item was scored by means of the following scoring system: 'yes' (Y) is '2'; 'partial' (P) is '1'; and 'no' (N) or 'unable to determine' (UD) is scored as '0'. The overall score is a percentage score of all 27 items. It was decided by the investigators to rate studies with an overall score of $\geq$60% as high quality. When disagreement in the overall score between the two independent reviewers was found, the specific items were discussed. In case no agreement was found a third reviewer (CV) was consulted.

Data extraction

Relevant data were systematically extracted and recorded upon a data-extraction form. The following data were extracted: number of patients, location of OA (hip and/or knee), specified criteria for diagnosis of OA, factors, outcome (methods of assessment of physical activity), and association between factors and outcome.

Best-evidence synthesis

Because observational studies in this systematic review were considered to be heterogeneous regarding the study population, methodological quality, factors and assessment of physical activity, we refrained from statistically pooling the data and performed a best-evidence synthesis. Only factors which were investigated in two or more studies were included in the best-evidence synthesis. The ranking levels of evidence were derived from van Tulder *et al.* and Yusuf *et al.*[24,25]. First, the studies were classified according to the type of study design. The preferred design was cohort study followed by case-control design and, at last, cross-sectional design. After that, the studies were ranked according to their methodologic quality score. The levels of evidence as applied within this study are presented in Table I. A result was consistent if the factor was significantly associated to physical activity with the same direction of the association.

Results

In total, the search strategy yielded 2,943 articles. After checking for double hits, 2,419 articles remained. As presented in the flow chart (Fig. 1), 42 articles remained for full text screening of which finally eight articles[11–14,26–29] met all inclusion criteria and were included in the present review. Screening of reference lists of included articles did not yield any additional articles.

Study characteristics

Five studies had a cross-sectional design[11,13,14,26,28] and three studies a case-control design[12,27,29]. However, since all three case-control studies only presented cross-sectional data on the

Table I
Best-evidence synthesis[24,25]

Strong evidence	Generally consistent findings in multiple high quality cohort studies.
Moderate evidence	Generally consistent findings in one high quality cohort study and $\geq$2 high quality case-control studies, or in $\geq$3 high quality case-control studies.
Limited evidence	(Generally consistent) findings in a single cohort study, or in maximum two case-control studies, or in multiple cross-sectional studies.
Conflicting evidence	Less than 75% of the studies reported consistent findings.
Insufficient evidence	Less than two low quality studies available.
No evidence	Provided when no studies could be found.

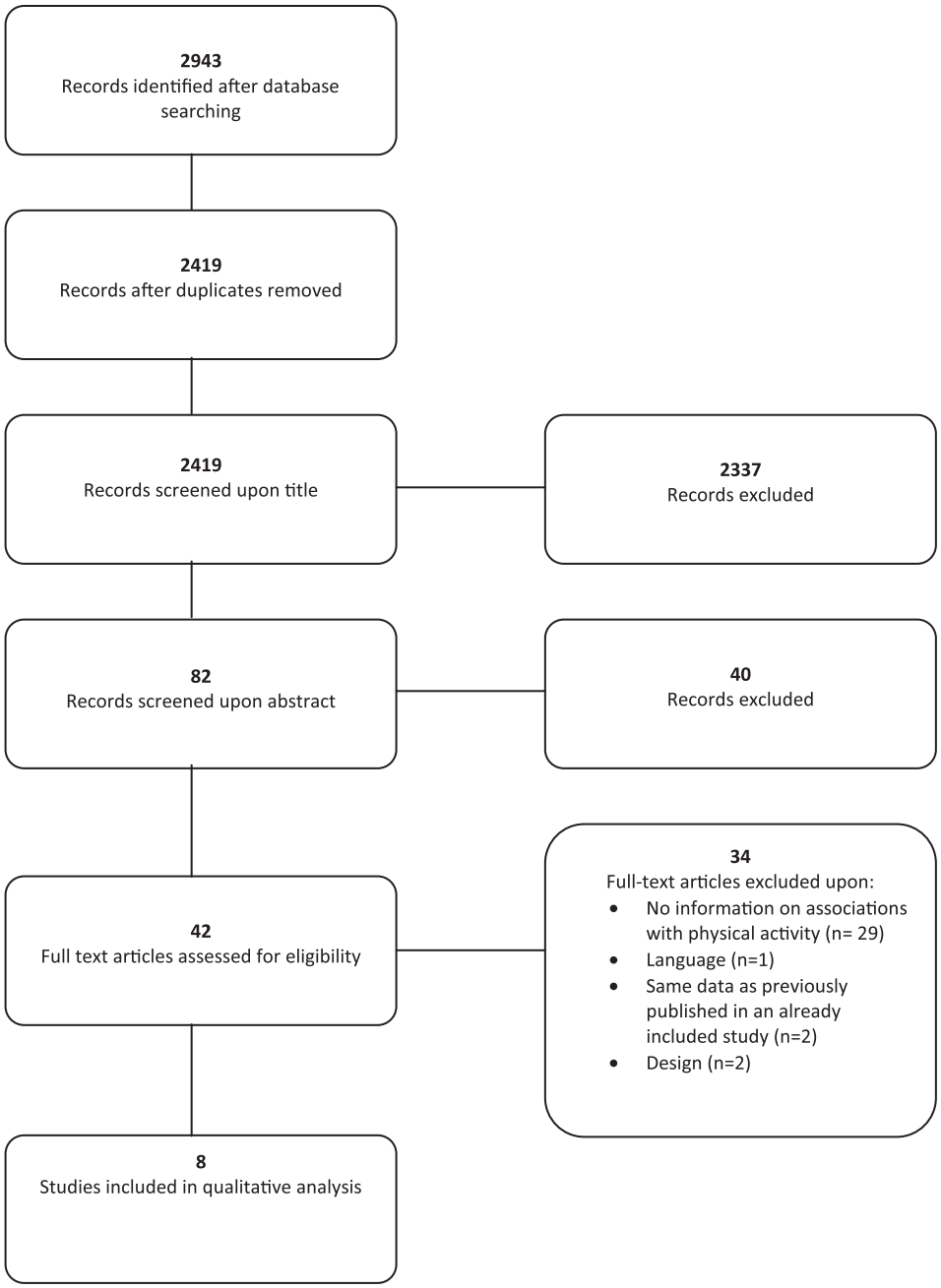

Fig. 1. Flow chart of inclusion procedure.

association between factors and the level of physical activity, all studies were considered to be cross-sectional (which results in, at most, limited evidence in the best-evidence synthesis). A full overview of study characteristics of the included studies is presented in Table II.

Methodological quality

There was initial disagreement between the two reviewers on 37% of the methodological quality items scored. Nearly all disagreements were due to reading errors or a difference in interpretation of the methodological quality criteria. After a consensus meeting, no disagreement persisted. Five studies[11,12,14,28,29] were rated as high quality (overall score $\geq$60%) and three studies as low quality[13,26,27]. The overall scores of methodological quality of the included studies are presented in Table II.

Factors related to the level of physical activity

Knee OA

Regarding patients with knee OA, there is limited evidence that a lower level of physical function is associated with a low level of physical activity (Table IIIa). Also, limited evidence was found that depression is not associated with the level of physical activity. Conflicting evidence was found for the association between the factors BMI, age, gender, number of coexisting disorders, level of education, pain and the level of physical activity. There is insufficient evidence for the association between the level of physical activity and the factors marital status, smoking, alcohol consumption, social support, mental health, disease duration, joint degeneration, fatigue, prescription of medication and prior knee symptoms.

Table II
The characteristics of the eight studies included in this systematic review, ordered by publication date

	Study design	Study population	Assessment of PA	Results: associations with lower level of physical activity	Quality score
Dunlop *et al.*, 2011[11]	Cross-sectional	Outpatients with OA of knee (radiological criteria) ($n = 2,678$)	Self-reported physical activity with the Physical Activity Scale for the Elderly (PASE)	Associations with older age, nonwhite background, female gender, less education, more comorbidities, lower physical performance, fewer prior knee symptoms and injuries and less alcohol consumption‡ No association with disease severity, knee pain, BMI, depressive symptoms, smoking‡	65%
Farr *et al.*, 2008[13]	Cross-sectional	Outpatients with early knee OA (ACR-criteria) ($n = 255$)	Accelerometer sensor at the right hip for 7 continuous days & Aerobics Centre Longitudinal Study Physical Activity Questionnaire (ACLS)	Associations with female gender, higher BMI‡ No associations with marital status, OA severity‡	56%
de Groot *et al.*, 2007[12]	Cross-sectional	Patients with end-stage hip or knee OA (radiological criteria) from outpatient clinic ($n = 84$)	Accelerometers sensors at the sternum and hips for 48 contiguous hours	Knee OA: Associations with higher age and higher BMI Hip OA: Associations with lower mental health No associations with gender, pain, stiffness, anxiety, depression, age (hip OA), BMI (hip OA) and mental health (knee OA)	74%
Hirata *et al.*, 2006[26]	Cross-sectional	Patients with hip OA (radiological criteria) from an outpatient clinic ($n = 65$)	Accelerometer sensor at the waist for 5–7 continuous days	Association with older age, higher BMI, lower gait function, lower joint function‡. Multivariate significant association with unemployment†, more joint degeneration* No association: hip involvement, past surgery and arthritis‡	54%
Murphy *et al.*, 2008[28]	Cross-sectional	Outpatients with OA of hip or knee (radiological criteria) ($n = 30$)	Accelerometer sensors at wrist for 5 continuous days	Association with activity pacing No association with age, physical function and medication use	61%
Murphy *et al.*, 2008[27]	Cross-sectional	Outpatients with OA of hip or knee (radiological criteria) ($n = 40$)	Accelerometer sensor at wrist for 5 continuous days	Association with higher fatigue, lower level of pain, lower level of physical function No association with age, BMI, depression, pain medication	54%
Rosemann *et al.*, 2007[14]	Cross-sectional	Primary care patients with hip and/or knee OA (ACR-criteria) ($n = 1,021$)	International Physical Activity Questionnaire (IPAQ)	For knee OA: Significant associations between low level of PA and low physical function of lower body, lower level of social support, more pain, higher BMI and higher age Hip OA: Significant associations between low level of PA and low physical function of lower body, lower level of social support, more pain, more depression and longer disease duration No association for number of comorbidities, marital status, gender, education, negative affect, joint degeneration, physical function upper body and prescription of pain relievers, depression (knee OA), disease duration (knee OA), BMI (hip OA) and age (hip OA)	65%
Thomas *et al.*, 2003[29]	Cross-sectional	End-stage knee OA – hospital based (radiological criteria), $n = 59$	Voorrips Questionnaire	Association with lower level of functional performance‡ No association: gender, pain‡	70%

n = number of patients; PA = physical activity.
† Association remains significant after adjustment for age and disease severity.
* Association remains significant after adjustment for age and employment.
‡ Univariate analyses.

Hip OA

In patients with hip OA, there is limited evidence that a low level of physical function is associated with a higher BMI, older age and a low level of physical activity (Table IIIb). There is conflicting evidence for the association between the level of physical activity and the factors depression, pain and joint degeneration. Furthermore, there is insufficient evidence on the association of the factors gender, level of education, marital status, employment status, number of coexisting disorders, social support, mental health, disease duration, fatigue, and prescription of medication with the level of physical activity.

Discussion

The objective of this study was to give an overview of factors associated with a low level of physical activity in patients with OA of the hip or knee. After a systematic search of the literature only eight studies were identified, all of cross-sectional design.

Most factors were found in the domain of individual factors. In patients with hip OA, limited evidence was found that higher BMI and older age were related with a lower level of physical activity. Both factors have often been reported in earlier research on factors associated with physical activity conducted within healthy populations and patients with arthritis[15,30–32]. However, in patients with knee OA the evidence of these associations is not clear. One high quality study (of Murphy *et al.*) did not find an association between BMI ($P = 0.11$) or age ($P = 0.18$) and the level of physical activity, compared to two (BMI) or three (age) high quality studies in which an association was found. This can probably be explained by the relatively low number of participants ($n = 40$) in this study, leading to low power. An association between age and/or BMI and physical activity was expected especially in patients with OA of the knee, since the impact of age and BMI on, for example, the course of physical function in patients with knee OA is also more clear and proven compared to patients with hip OA[6,33].

Table IIIa
Overview of findings regarding associations with a low level of physical activity in patients with knee OA

	Association found	No association found	Level of evidence
Individual factors			
Higher BMI (kg/m^2)	Two HQ and one LQ cross-sectional studies[12–14]	One HQ and one LQ cross-sectional studies[11,27,*]	Conflicting evidence
Older age	Three HQ cross-sectional studies[11,12,14]	One HQ and one LQ cross-sectional studies[27,28]	Conflicting evidence
Female gender	One HQ cross-sectional study[11,*]	Two HQ cross-sectional studies[14,29,*]	Conflicting evidence
Higher number of coexisting disorders	One HQ cross-sectional study[11,*]	One HQ cross-sectional study[14]	Conflicting evidence
Lower level of education	One HQ cross-sectional study[11,*]	One HQ cross-sectional study[14]	Conflicting evidence
Psychological factors			
Depression		Three HQ and one LQ cross-sectional studies[11,12,14,27]	Limited evidence
Illness-related factors			
More pain	One HQ and one LQ cross-sectional studies[14,27]	Three HQ cross-sectional studies[11,12,29]	Conflicting evidence
Lower level of physical function	One LQ and three HQ cross-sectional study[11,14,27,29]	One HQ cross-sectional study[28]	Limited evidence

HQ = high quality study; LQ = low quality study.
* Only univariate analyses have been performed.

In the domain of psychological factors, conflicting evidence was found regarding the relationship between greater depression and avoidance of physical activity in patients with hip OA. However, limited evidence was found that there is no association between depression and the level of physical activity in patients with knee OA. Besides methodological explanations (only cross-sectional studies were included, no uniform measure for depression), we cannot explain this finding. It was expected that more depression was associated with a lower level of physical activity, since depression is a risk factor for functional decline in patients with OA[6,33] and negative affect, such as depression, is thought to strengthen the tendency to avoid activity[34,35].

Regarding illness-related factors, there is limited evidence that there is an association between a low level of physical function and a low level of physical activity, both in hip and knee OA. Since all included studies had a cross-sectional design, no information is available on the causality of these factors. As is stated in the avoidance model, it is expected that these two factors interfere with each other and a decrease in one of the aspects leads to a decrease in the other aspect[17,34]. This result also complies with the graded relationship between physical activity and functional performance, as was found by Dunlop *et al.*[11]. They concluded that physical activity has benefit regardless of the level of physical activity that is achieved. Therefore, especially patients with a low level of physical function need to be advised and stimulated to perform (even a low level of) physical activity.

Furthermore, there is conflicting evidence that there is no association between pain and a low level of physical activity both in patients with knee and hip OA. The fact that conflicting evidence was found of the association between pain and physical activity is remarkable, since, in daily practice, patients with hip and/or knee OA often complain about pain and pain is one of the main criteria for total joint replacement[36,37]. Therefore, it was expected that pain would be strongly related to a low level of physical activity. On the other hand, some patients with a lot of pain remain physical active while others, with the same amount of pain, become sedentary. Apparently, as is presented in the avoidance model, the coping strategy of patients is more related to the level of activity than the pain patients experience. Unfortunately, no studies included coping as a factor of physical activity. In future research the association between coping strategy and the level of physical activity should be elaborated.

A few limitations of this study need to be mentioned. First, the variety in assessment of physical activity. The studies included within the present review, used accelerometers[12,26–28], questionnaires[11,14,29] or both[13] which probably influenced the results of our study since accelerometers and questionnaires on physical activity are not highly correlated[38]. Therefore, more studies need to be performed on physical activity in patients with OA using more uniform measures of physical activity (e.g., a combination of questionnaires and accelerometers). However, at this moment no specific instrument can be recommended to measure physical activity in patient with OA[38]. Another comment that needs to be made is that only cross-sectional studies were included in this review. As a consequence only limited evidence of associations with physical activity could be found. To get insight in determinants of physical activity in patients with OA, studies with a longitudinal design, preferably cohort studies, need to be performed. Furthermore, the number of participants of the included studies varied between 30 and 2,678. This might lead to bias, since small associations are significant in large studies and not in small studies. Since not all studies presented the size of the association (but only the *P*-value or mean values of physical activity for different groups), we cannot preclude that the results are biased by this. Finally,

Table IIIb
Overview of findings regarding associations with a low level of physical activity in patients with hip OA

	Association found	No association found	Level of evidence
Individual factors			
Higher BMI (kg/m^2)	One LQ cross-sectional study[26,*]	Two HQ and one LQ cross-sectional studies[12,14,27]	Limited evidence
Older age	One LQ cross-sectional study[26,*]	Three HQ and one LQ cross-sectional studies[12,14,27,28]	Limited evidence
Psychological factors			
More depression	One HQ cross-sectional study[14]	One HQ and one LQ cross-sectional study[12,27]	Conflicting evidence
Illness-related factors			
More pain	One HQ and one LQ cross-sectional studies[14,27]	One HQ cross-sectional studies[12]	Conflicting evidence
Greater joint degeneration	One LQ cross-sectional study[26]	One HQ cross-sectional study[14]	Conflicting evidence
Lower levels of physical function	One HQ and two LQ cross-sectional studies[14,26,27]	One HQ cross-sectional study[28]	Limited evidence

* Only univariate analyses have been performed.

attention should be given to the rather large disagreement (on 37% of the items) between the two reviewers on the methodological quality of the study. This large disagreement was due to reading errors, differences in interpretation of the methodological criteria and the fact that one of reviewers was rather inexperienced. Moreover, the extensive scoring ability, which the instrument EAI provides, may have been influential as well. Reducing the scoring options into only 'yes' or 'no', instead of including 'partial' may increase the ease of use of the EAI and may have led to less initial disagreement between the two reviewers. However, in this study the disagreement was solved after a consensus meeting.

Although all patients with OA should be advised to perform physical activity, the results of this study suggest that especially patients with OA of high age (hip OA), with a high BMI (hip OA) and a low level of physical function (both hip and knee OA) need extra stimulation from clinicians to be more physically active. Also, interventions focussing on physical activity should include attention for the reduction of body weight and the improvement of physical function. However, the levels of evidence in this study were only limited. Furthermore, because of the cross-sectional design of the included studies within this review, causality between factors and the level of physical activity could not be determined. Before new strategies and interventions to increase physical activity in patients with OA can be developed, high quality longitudinal studies need to be performed to get more insight in the causality between factors and the level of physical activity.

Contribution of authors

Conception and design (PA Huisman, JA Bartens, MF Pisters, T Takken, C Veenhof).

Analysis and interpretation of the data (PA Huisman, JA Bartens, MF Pisters, C Veenhof).

Drafting of the article (PA Huisman, JA Bartens, MF Pisters, C Veenhof).

Critical revision of the article for important intellectual content (PA Huisman, JA Bartens, MF Pisters, T Takken, C Veenhof).

Final approval of article (PA Huisman, JA Bartens, MF Pisters, T Takken, C Veenhof).

Conflict of interest

None of the authors has competing interests.

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Appendix 1. Search strategy PubMed

("Osteoarthritis, hip"[MeSH Terms] OR "osteoarthritis, knee"[MeSH Terms] OR Knee osteoarthritis[tw] OR Hip osteoarthritis[tw] OR Lower-extremity osteoarthritis[tw]) AND ("motor activity"[MeSH Terms] OR "activities of daily living"[MeSH Terms] OR ADL[tw] OR Daily activity[tw] OR Physical activity[tw] OR Physical inactivity[tw] OR Activity limitation[tw] OR Avoidance activity[tw]) AND ("humans"[MeSH Terms]).

Supplementary material

Supplementary data related to this article can be found online at doi:10.1016/j.joca.2011.10.006.

References

1. Katz JD, Nayyar G. Introduction: arthritis and myositis. Ann N Y Acad Sci 2009;1154:3–9.
2. Poos MJJC, Gommer AM. Hoe vaak komt artrose voor en hoeveel mensen sterven eraan?. In: Volksgezondheid Toekomst Verkenner. Nationaal Kompas Volksgezondheid. Bilthoven: RIVM; 24-6-2009.
3. McAlindon TE, Cooper C, Kirwan JR, Dieppe PA. Determinants of disability in osteoarthritis of the knee. Ann Rheum Dis 1993;52(4):258–62.
4. van Baar ME, Dekker J, Lemmens JA, Oostendorp RA, Bijlsma JW. Pain and disability in patients with osteoarthritis of hip or knee: the relationship with articular, kinesiological, and psychological characteristics. J Rheumatol 1998;25(1):125–33.
5. Sharma L, Cahue S, Song J, Hayes K, Pai YC, Dunlop D. Physical functioning over three years in knee osteoarthritis: role of psychosocial, local mechanical, and neuromuscular factors. Arthritis Rheum 2003;48(12):3359–70.
6. Dekker J, van Dijk GM, Veenhof C. Risk factors for functional decline in osteoarthritis of the hip or knee. Curr Opin Rheumatol 2009;21(5):520–4.
7. Dunlop DD, Semanik P, Song J, Mancheim M, Shih V, Chang RW. Risk factors for functional decline in older adults with arthritis. Arthritis Rheum 2005;52(4):1274–82.
8. Dunlop DD, Semanik P, Song J, Sharma L, Nevitt M, Jackson R, *et al*. Moving to maintain function in knee osteoarthritis: evidence from the osteoarthritis initiative. Arch Phys Med Rehabil 2010;91(5):714–21.
9. Haskell WL, I-Min L, Pate RR, Powell KE, Blair SN, Franklin BA, *et al*. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39(8):1423–34.
10. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, *et al*. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39(8):1435–55.
11. Dunlop DD, Song J, Semanik PA, Sharma L, Chang RW. Physical activity levels and functional performance in the osteoarthritis initiative: a graded relationship. Arthritis Rheum 2011;63(1):127–36.
12. de Groot IB, Bussmann JB, Stam HJ, Verhaar JA. Actual everyday physical activity in patients with end-stage hip or knee osteoarthritis compared with healthy controls. Osteoarthritis Cartilage 2008;16(4):436–42.
13. Farr JN, Going SB, Lohman TG, Rankin L, Kasle S, Cornett M, *et al*. Physical activity levels in patients with early knee osteoarthritis measured by accelerometry. Arthritis Rheum 2008;59(9):1229–36.
14. Rosemann T, Kuehlein T, Laux G, Szecsenyi J. Factors associated with physical activity of patients with osteoarthritis of the lower limb. J Eval Clin Pract 2008;14(2):288–93.
15. Shih M, Hootman JM, Kruger J, Helmick CG. Physical activity in men and women with arthritis National Health Interview Survey, 2002. Am J Prev Med 2006;30(5):385–93.
16. Somers TJ, Keefe FJ, Pells JJ, Dixon KE, Waters SJ, Riordan PA, *et al*. Pain catastrophizing and pain-related fear in osteoarthritis patients: relationships to pain and disability. J Pain Symptom Manage 2009;37(5):863–72.
17. Steultjens MP, Dekker J, Bijlsma JW. Avoidance of activity and disability in patients with osteoarthritis of the knee: the mediating role of muscle strength. Arthritis Rheum 2002;46(7):1784–8.

18. Marks R, Allegrante JP. Chronic osteoarthritis and adherence to exercise: a review of the literature. J Aging Phys Act 2005;13(4):434–60.
19. Pisters MF, Veenhof C, de Bakker DH, Schellevis FG, Dekker J. Long-term effect of exercise therapy in patients with osteoarthritis of the hip or knee: a randomized controlled trial comparing two different physiotherapy interventions. Submitted 2009.
20. Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K, *et al*. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. Arthritis Rheum 1986;29(8): 1039–49.
21. Altman R, Alarcon G, Appelrouth D, Bloch D, Borenstein D, Brandt K, *et al*. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip. Arthritis Rheum 1991;34(5):505–14.
22. Kellgren JH, Lawrence JS. Radiological assessment of osteoarthrosis. Ann Rheum Dis 1957;16(4):494–502.
23. Genaidy AM, Lemasters GK, Lockey J, Succop P, Deddens J, Sobeih T, *et al*. An epidemiological appraisal instrument – a tool for evaluation of epidemiological studies. Ergonomics 2007;50(6):920–60.
24. van Tulder M, Furlan A, Bombardier C, Bouter L. Updated method guidelines for systematic reviews in the cochrane collaboration back review group. Spine 2003;28(12):1290–9.
25. Yusuf E, Nelissen RG, Ioan-Facsinay A, Stojanovic-Susulic V, DeGroot J, van Osch G, *et al*. Association between weight or body mass index and hand osteoarthritis: a systematic review. Ann Rheum Dis 2010;69(4):761–5.
26. Hirata S, Ono R, Yamada M, Takikawa S, Nishiyama T, Hasuda K, *et al*. Ambulatory physical activity, disease severity, and employment status in adult women with osteoarthritis of the hip. J Rheumatol 2006;33(5):939–45.
27. Murphy SL, Smith DM, Clauw DJ, Alexander NB. The impact of momentary pain and fatigue on physical activity in women with osteoarthritis. Arthritis Rheum 2008;59(6):849–56.
28. Murphy SL, Smith DM, Alexander NB. Measuring activity pacing in women with lower-extremity osteoarthritis: a pilot study. Am J Occup Ther 2008;62(3):329–34.
29. Thomas SG, Pagura SM, Kennedy D. Physical activity and its relationship to physical performance in patients with end stage knee osteoarthritis. J Orthop Sports Phys Ther 2003; 33(12):745–54.
30. Belza B, Topolski T, Kinne S, Patrick DL, Ramsey SD. Does adherence make a difference? Results from a community-based aquatic exercise program. Nurs Res 2002;51(5):285–91.
31. Petersen L, Schnohr P, Sorensen TI. Longitudinal study of the long-term relation between physical activity and obesity in adults. Int J Obes Relat Metab Disord 2004;28(1):105–12.
32. Hootman JM, Macera CA, Ham SA, Helmick CG, Sniezek JE. Physical activity levels among the general US adult population and in adults with and without arthritis. Arthritis Rheum 2003;49(1):129–35.
33. van Dijk GM, Dekker J, Veenhof C, Van den Ende CH. Course of functional status and pain in osteoarthritis of the hip or knee: a systematic review of the literature. Arthritis Rheum 2006; 55(5):779–85.
34. Dekker J, Tola P, Aufdemkampe G, Winckers M. Negative affect, pain and disability in osteoarthritis patients: the mediating role of muscle weakness. Behav Res Ther 1993;31(2):203–6.
35. Keefe FJ, Caldwell DS, Queen K, Gil KM, Martinez S, Crisson JE, *et al*. Osteoarthritic knee pain: a behavioral analysis. Pain 1987;28(3):309–21.
36. McHugh GA, Luker KA. Influences on individuals with osteoarthritis in deciding to undergo a hip or knee joint replacement: a qualitative study. Disabil Rehabil 2009;31(15): 1257–66.
37. Woolhead GM, Donovan JL, Chard JA, Dieppe PA. Who should have priority for a knee joint replacement? Rheumatology (Oxford) 2002;41(4):390–4.
38. Terwee CB, Bouwmeester W, van Elsland SL, de Vet HC, Dekker J. Instruments to assess physical activity in patients with osteoarthritis of the hip or knee: a systematic review of measurement properties. Osteoarthritis Cartilage 2011.