Arthritis Care & Research
Vol. 68, No. 2, February 2016, pp 228–236
DOI 10.1002/acr.22669

ORIGINAL ARTICLE

Physical Activity Patterns Among Older Adults With and Without Knee Osteoarthritis in Six European Countries

FLORIAN HERBOLSHEIMER,[1] LAURA A. SCHAAP,[2] MARK H. EDWARDS,[3] STEFANIA MAGGI,[4] ÁNGEL OTERO,[5] ERIK J. TIMMERMANS,[2] MICHAEL D. DENKINGER,[1] SUZAN VAN DER PAS,[2] JOOST DEKKER,[2] CYRUS COOPER,[3] ELAINE M. DENNISON,[3] NATASJA M. VAN SCHOOR,[2] RICHARD PETER,[1] AND THE EPOSA STUDY GROUP

Objective. **To investigate patterns of physical activity in older adults with knee osteoarthritis (OA) compared to older adults without knee OA across 6 European countries. We expect country-specific differences in the physical activity levels between persons with knee OA compared to persons without knee OA. A varying degree of physical activity levels across countries would express a facilitating or impeding influence of the social, environmental, and other contextual factors on a physically active lifestyle.**

Methods. **Baseline cross-sectional data from the European Project on Osteoarthritis were analyzed. In total, 2,551 participants from 6 European countries (Germany, Italy, The Netherlands, Spain, Sweden, and the UK) were included.**

Results. **Participants with knee OA were less likely to follow physical activity recommendations and had poorer overall physical activity profiles than those without knee OA (mean 62.9 versus 81.5 minutes/day, respectively; $P = 0.015$). The magnitude of this difference varied across countries. Detailed analysis showed that low physical activity levels in persons with knee OA could be attributed to less everyday walking time (odds ratio 1.31, 95% confidence interval 1.07–1.62).**

Conclusion. **This study highlighted the fact that having knee OA is associated with a varying degree of physical activity patterns in different countries. This national variation implies that low levels of physical activity among persons with knee OA cannot be explained exclusively by individual or disease-specific factors, but that social, environmental, and other contextual factors should also be taken into account.**

INTRODUCTION

Osteoarthritis (OA) is the most prevalent form of arthritis and a major source of disability (1). In 2004, OA was considered to be responsible for 97% of all knee replacements in the US. In an international comparison, Europe and the Western Pacific region ranked highest in OA disease burden using disability-adjusted life years (2).

Health benefits of physical activity are well established. Engaging in a physically active lifestyle delays disability and promotes OA-specific benefits, including maintaining physical function and decreasing pain, depression, and fatigue (3–6). Physical activity has been shown to delay the progression of OA and of functional limitations (7).

The Indicators for Monitoring COPD and Asthma–Activity and Function in the Elderly in Ulm study was supported by the European Union (No. 2005121) and the Ministry of Science, Baden-Württemberg. The Italian cohort study is part of the National Research Council Project on Aging. The Longitudinal Aging Study Amsterdam was supported by the Dutch Ministry of Health, Welfare and Sports. The Peñagrande study was partially supported by the National Fund for Health Research (Fondo de Investigaciones en Salud) of Spain (project numbers FIS PI 05/1898, FIS RETICEF RD06/0013/1013, and FIS PS09/02143). The Swedish Twin Registry was supported in part by the Swedish Ministry of Higher Education. The Hertfordshire Cohort Study was supported by the Medical Research Council, UK.

[1]Florian Herbolsheimer, Diploma, Michael D. Denkinger, MD, Richard Peter, PhD: Ulm University, Ulm, Germany; [2]Laura A. Schaap, PhD, Erik J. Timmermans, MSc, Suzan van der Pas, PhD, Joost Dekker, PhD, Natasja M. van Schoor, PhD: VU University Medical Center, Amsterdam, The Netherlands; [3]Mark H. Edwards, PhD, Cyrus Cooper, PhD, Elaine M. Dennison, PhD: University of Southampton and Southampton General Hospital, Southampton, UK; [4]Stefania Maggi, PhD: University of Padua and National Research Council, Padua, Italy; [5]Ángel Otero, MD: Faculty of Medicine, Universidad Autonoma de Madrid, Madrid, Spain.

Address correspondence to Florian Herbolsheimer, Diploma, Institute of the History, Philosophy and Ethics of Medicine, Ulm University, Parkstrasse 11, 89081 Ulm, Germany. E-mail: florian.herbolsheimer@uni-ulm.de.

Submitted for publication November 26, 2014; accepted in revised form July 14, 2015.

Significance & Innovations

- Knee osteoarthritis (OA) is associated with lower physical activity levels.
- There are country-specific variations in the associations of physical activity and knee OA.
- Physical activity differences between persons with and without knee OA could be traced back to less daily walking time.
- Social, environmental, and other contextual factors influence limitations of physical activity levels in people with knee OA.

Some evidence suggests that lack of physical activity leads to muscle strength destabilization of the knee, with a greater risk of developing or worsening OA (8). Accordingly, aerobic exercise (9) and resistance exercise (10,11) have been shown to be beneficial for OA patients and have resulted in improved gait and function. Moderate levels of physical activity are recommended for persons with OA, provided the activity is not painful (12). The American College of Rheumatology (ACR) has identified exercise programs as first-line nonpharmacologic treatment and physical activity as one of the main targets in arthritis management programs for OA patients (13,14). This corresponds with a recent review of guidelines and recommendations for the management of OA. The authors of that review found a broad agreement for the beneficial effect of low-intensity exercise for knee and hip OA in 12 of 15 recommendations (15).

Despite these varied beneficial effects of physical activity, research has shown that people with OA engage less in physical activities than persons without OA (16). This finding is consistent with epidemiologic data from the US that has repeatedly documented a high prevalence of inactivity among adults with arthritis (17,18). Earlier studies revealed that half of all persons with radiographic knee OA were inactive, and only 10.2% met physical activity recommendations of 150 minutes of moderate-to-vigorous physical activity (MVPA) per week (16). Similarly, early-stage OA patients spent more time on moderate than on vigorous physical activity, with only a minority of 30% achieving recommended levels (19).

Previous studies have shown a substantial variation in population estimates of physical activity (20,21). Country-specific prevalence rates of physical inactivity ranged internationally from 1.6% to 51.7% in a World Health Survey (22). However, most studies have focused on a single country when examining the association between physical activity and knee OA. Consequently, there is little knowledge about country-specific differences in both physical activity and knee OA. We would expect the same patterns of physical activity and knee OA across all 6 European countries if this association is solely caused by disease-specific factors. However, we hypothesize that country-specific variations remain in the association between physical inactivity and knee OA that cannot be explained exclusively by disease-specific factors.

This study investigates differences in physical activity levels between persons with and without OA in the knee across 6 European countries, using the same assessments for knee OA and physical activity in all countries. We assume that the same pathophysiologic process does not necessary lead to the same physical activity patterns in those living with knee OA. Instead, different social factors (i.e., social networks, descriptive norms in peer groups), environmental factors (i.e., climate), public policies promoting physical activity, and other contextual factors in the different countries can probably facilitate or impede a person's ability to cope with the disease and build up a physically active lifestyle. Therefore, we hypothesize that the association between knee OA and physical activity differs among the 6 European countries. We additionally studied different domains of physical activity to examine more closely in which countries persons with knee OA differ most from persons without knee OA.

SUBJECTS AND METHODS

Data source. The analyses used cross-sectional data of the European Project on Osteoarthritis (EPOSA) that included 2,942 participants. EPOSA is an observational, population-based study including data from 6 European cohort studies (Germany, Italy, The Netherlands, Spain, Sweden, and the UK) on older community-dwelling persons ages 65–85 years in all cohorts except for the UK, which has an age range of 71–79 years. A detailed description of the cohorts and the measurements is published elsewhere (23).

Using a complete-case design, we excluded 13% of the participants from further analysis because at least 1 study variable was missing (Figure 1). The excluded persons were significantly older ($\delta = 1.5$ years; $P < 0.001$) and had more comorbidities ($P = 0.005$). They did not differ in education level, sex ratio, body mass index (BMI), and the percentage of having knee OA.

Variables. Data collection started between November 2010 and March 2011 in all 6 countries and ended between September and November 2011. Trained study nurses interviewed all participants at home or in a clinical center. The study incorporated a standardized questionnaire as well as a clinical examination.

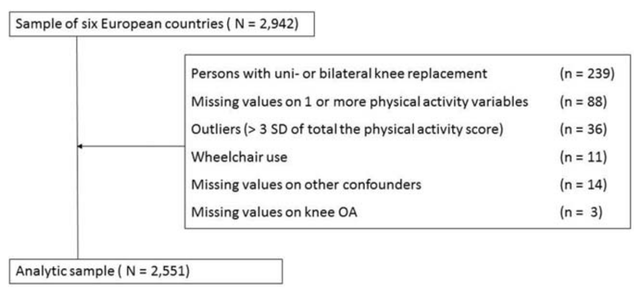

Figure 1. Strengthening the Reporting of Observational Studies in Epidemiology diagram showing criteria for excluding participants. OA = osteoarthritis.

Physical activities were measured using the validated Longitudinal Aging Study Amsterdam (LASA) Physical Activity Questionnaire (LAPAQ). The LAPAQ was found to be highly correlated with a diary covering 7 days ($r = 0.68$, $P < 0.001$) as well as moderately correlated with a pedometer ($r = 0.56$, $P < 0.001$) (24). The questionnaire consists of frequencies (i.e., How many times did you walk during the past 2 weeks?) and duration (i.e., How long did you usually walk each time?) of 6 activities in the previous 2 weeks. The activities are daily walking, daily cycling, gardening, light household work, heavy household work, and a maximum of 2 types of sports. Daily walking and daily cycling were not classified as types of sports if they were a means to perform everyday activities, like walking or cycling to the supermarket. In order to calculate the daily activity, the frequency and duration were multiplied and divided by 14 days. A total activity score was calculated by adding up walking, cycling, gardening, and sports. Light and heavy household activities were excluded from calculation because a factor analysis (not shown) revealed that household activities load on a different factor than all other activities. It is questionable whether household activities provide all of the benefits that are normally associated with meeting the physical activity guidelines (25). Extreme outliers (>3 SD, n = 36) were separately identified for each country and subsequently removed from further analysis.

We additionally provided information if participants followed recommended levels of physical activity. Current physical activity guidelines for adults and older adults recommend at least 150 minutes per week of MVPA (26). Time spent for sport activities as well as everyday cycling was summed up if the particular physical activity was coded equal to or greater than 3 metabolic equivalents (METs) (27). We decided to classify daily walking activity as a low-intensity physical activity with MET scores <3 (i.e., walking 2.0 mph on a firm surface).

Knee OA was diagnosed based on the criteria of the ACR designed for use in epidemiologic studies (28,29). The knee OA clinical diagnosis required pain in the knee as evaluated by the Western Ontario and McMaster Universities Arthritis Index (WOMAC) pain subscale score, plus 3 of the following criteria: age >50 years; morning stiffness lasting <30 minutes, evaluated by the WOMAC stiffness subscale; crepitus on active motion on at least 1 side; bony tenderness on at least 1 side; bony enlargement on at least 1 side; and no palpable warmth of synovium in both knees. The EPOSA study group has chosen a WOMAC pain cut point of ≥3 (23).

Other studies have shown that confounders regarding the association between physical activity and knee OA influence results substantially (30). To address this issue, the following variables were considered as potential confounders in the analyses: age in years, sex, and educational attainment, which summarizes the highest achieved level of school education, classified as elementary school not completed (none), elementary school completed (low), vocational or general secondary education (middle), and college or university education (high). Further confounders were clinical diagnosis of hip OA (23) and the average daily temperature (in degrees Celsius) recorded for each day and each participant, summarized for the previous 14 days. These data were extracted from local weather stations within a maximum distance from the participant's residence of 80 km. Additionally, we have explored BMI from measured height and weight (kg/m^2). If 1 item was missing (n = 39), self-reported height or weight was used instead. The comorbidity index summarizes the number of chronic diseases (chronic nonspecific lung disease, cardiovascular diseases, peripheral arterial disease, stroke, diabetes mellitus, osteoporosis, and cancer) and ranges from 0 to 7. At the end of the physical activity questionnaire we asked the participants if the past 2 weeks were or were not normal compared to the rest of the previous year. Based on this question, we created 3 dummy variables indicating reasons (disease, depression, or nice weather) for deviating from physical activity levels.

Statistical analysis. Differences in characteristics between adults with and without knee OA were tested using one-way analysis of variance for normally distributed variables, the Kruskal-Wallis tests for skewed variables, and Pearson's chi-square tests for categorical variables. Country differences in total physical activity level were analyzed with a multivariate linear regression analysis. The different subdomains of the total physical activity score (e.g., walking, cycling, and gardening) were divided into tertiles in order to account for the skewed distribution of these variables. Ordinal logistic regression models were applied with the lowest tertile as reference. Furthermore, a logistic regression was calculated predicting the probability of achieving the recommendation of 150 minutes of MVPA per week.

We examined the associations between the total physical activity score and knee OA and adjusted for all known potential confounding factors, such as sex, age, comorbidity, BMI, hip OA, average temperature, and 3 dichotomous variables indicating reasons for irregular physical activity. To examine country differences, we calculated our model in 2 steps: first, we added the 2 main effects of knee OA and country fixed effects into the model by using country dummy variables and applying the UK as reference category. In a second step, we added the interaction effect of country and knee OA, again using the UK as reference. In a further step, stratified analyses were performed by country if some of the interaction effects of knee OA and country reached significance. Afterwards, we calculated the effect of knee OA on different domains of physical activity, including walking, cycling, and gardening. The data were analyzed using STATA software, version 10.1.

RESULTS

Compared to older adults without knee OA, participants with knee OA were more likely to be less educated, obese, and female, to have more chronic diseases, and to engage in significantly lower levels of sport and walking activities. This tendency is reflected in a significantly lower total activity score and a significantly lower percentage of persons following recommendations for physical activity (Table 1).

Knee OA was significantly associated with a low physical activity score (Table 2). Subjects with knee OA were on average 10.2 minutes/day ($P = 0.011$) less physically

Table 1. Demographic characteristics and physical activity by OA status*

Characteristics	No knee OA (n = 2,141)	Knee OA (n = 410)	*P*
Demographics			
Age at time of interview, years	73.9 ± 5.1	74.4 ± 5.1	0.088
Female	48.3	66.3	< 0.001
Education, highest level			< 0.001
Primary school incomplete	9.6	18.8	
Primary school	33.4	34.9	
Secondary school/college	34.8	32.4	
University	22.2	13.9	
Physical health			
Comorbidity index (range 1–7)	1.0 ± 1.0	1.2 ± 1.1	< 0.001
BMI (kg/m^2)	27.3 ± 4.2	29.4 ± 4.8	< 0.001
Irregular physical activity in past 2 weeks†			
Disease	8.0	11.0	0.050
Depression	0.6	0.5	0.772
Nice weather	1.7	2.7	0.167
Average temperature, °C‡	12.0 ± 5.5	12.3 ± 5.6	0.279
Physical activity, minutes/day			
Total physical activity§	96.1 ± 86.6	75.1 ± 71.3	< 0.001
Walking	33.7 ± 40.1	29.0 ± 40.4	0.007
Cycling	5.7 ± 17.9	4.3 ± 13.3	0.177
Sport activities	30.1 ± 42.0	20.0 ± 36.3	0.009
Gardening	32.3 ± 61.4	22.0 ± 42.6	0.011
Following physical activity recommendations¶	40.1	34.9	0.046

* Values are mean ± SD or percentage, unless otherwise indicated. OA = osteoarthritis; BMI = body mass index.
† Subjects were asked "Why were the past two weeks not normal (compared to the rest of the year)."
‡ Temperature of the last 2 weeks before the interview was conducted.
§ Total Longitudinal Aging Study Amsterdam Physical Activity Questionnaire score without household activities.
¶ >150 minutes per week of moderate-to-vigorous physical activity.

active than persons without the condition. The UK was selected as reference category in the following linear regression models, as the effect of knee OA was most strongly pronounced in this country. The analyses show that overall physical activity levels as well as the effect of knee OA on physical activity vary significantly between some countries. The Netherlands, Sweden, and Spain showed, compared to the UK, overall lower physical activity

Table 2. Adjusted means, t-values, and *P* values for linear regression models testing total physical activity by knee OA affected joints and country interactions*

	Model 1			Model 2		
	B	t-value	*P*	*B*	t-value	*P*
Intercept	268.26	10.03	< 0.001	273.02	10.20	< 0.001
Knee OA	−10.17	−2.54	0.011	−31.69	−3.08	0.002
Country						
UK (ref.)						
Spain	−32.51	−5.05	< 0.001	−35.67	−6.31	< 0.001
Germany	11.11	1.72	0.086	9.44	1.33	0.184
Sweden	−29.65	−5.35	< 0.001	−34.50	−5.68	< 0.001
Italy	−9.99	−1.43	0.154	−11.48	−1.47	0.143
The Netherlands	−42.80	−7.91	< 0.001	−47.35	−8.10	< 0.001
Interaction terms†						
Knee OA UK (ref.)						
Knee OA Spain				23.57	2.02	0.044
Knee OA Germany				11.70	0.76	0.449
Knee OA Sweden				33.50	2.61	0.009
Knee OA Italy				15.43	0.95	0.344
Knee OA The Netherlands				35.54	2.89	0.004
Adjusted R^2			0.151			0.153

* OA = osteoarthritis; ref. = reference.
† Adjusted for hip OA, hip and knee OA, body mass index, comorbidities, age, sex, average temperature in the previous 2 weeks, and disease, depression, or nice weather in the previous 2 weeks.

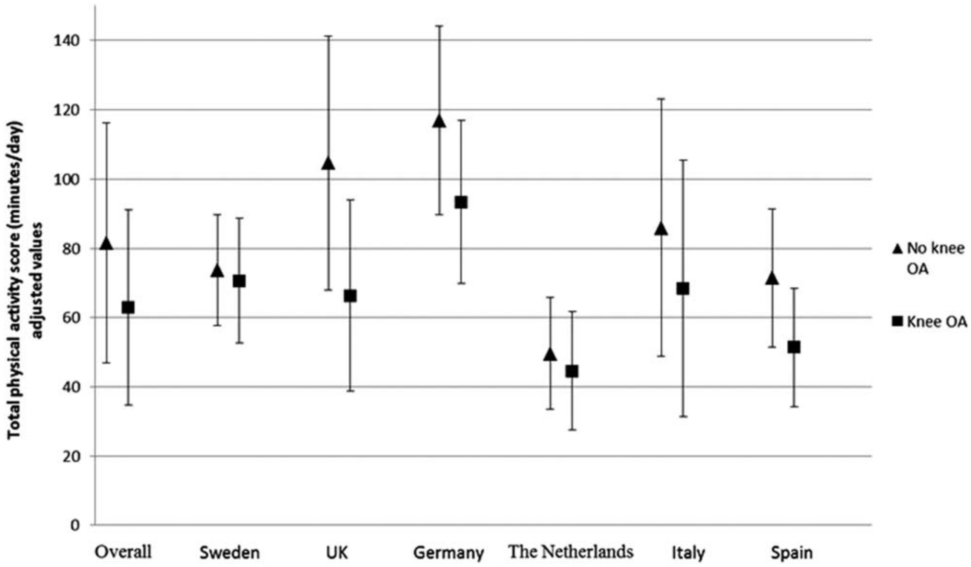

Figure 2. Association of total daily physical activity with knee osteoarthritis (OA) in 6 countries. Adjusted for sex, age, body mass index, and comorbidities, as well as average temperature, knee OA, hip OA, and irregular physical activity in the previous 2 weeks. Error bars represent 1 SD.

levels. Besides the main effects of knee OA and the main effect of country, we found country-specific variations of the effect of knee OA on physical activity that were significantly lower in The Netherlands, Sweden, and Spain compared to the UK. All models were adjusted for sex, age, BMI, hip OA, comorbidity, reasons for irregular physical activity, and

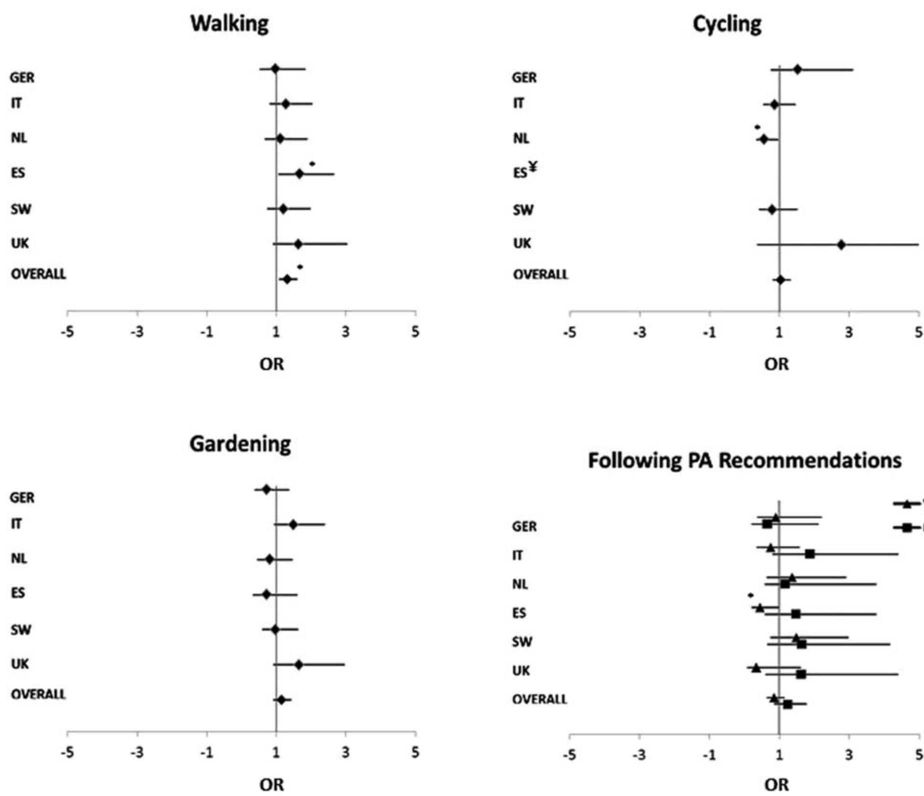

Figure 3. Odds ratios (ORs) with 95% confidence interval for being in the lowest tertile of physical activity in persons with and without knee osteoarthritis (OA) across countries and stratified by different domains of physical activity, adjusted for sex, age, body mass index, comorbidities, and average temperature, as well as hip OA, hip and knee OA, and irregular physical activity (PA) in the previous 2 weeks. GER = Germany; IT = Italy; NL = The Netherlands; ES = Spain; SW = Sweden; UK = - United Kingdom; * $P < 0.05$; ¥ = insufficient cases, model does not converge.

average temperature. Results did not change when using a bootstrapping procedure based on 500 bootstrapping samples in order to account for a non-normal distribution of the total physical activity levels.

Figure 2 illustrates the associations of adjusted total daily activity duration with knee OA stratified by country. The absolute amount of physical activity varies across Europe and ranges from mean ± SD 114.3 ± 27.7 minutes/day in Germany to 48.9 ± 16.3 minutes/day in The Netherlands. Country-specific analysis that compared individuals with and without knee OA showed substantially decreased physical activity levels in the UK ($P = 0.010$).

Figure 3 displays ordinal logistic regression estimates with the LAPAQ subscores (walking, cycling, and gardening) as dependent variables in persons with knee OA. The fourth graph represents the results of a logistic regression estimating the probability of achieving recommended physical activity levels as a dependent variable and was stratified by sex for exploratory reasons. Women are less likely to follow physical activity recommendations compared to men (in Spain: odds ratio [OR] 0.78, 95% confidence interval [95% CI] 0.65–0.91). The overall association between knee OA and doing less walking remained significant (OR 1.31, 95% CI 1.07–1.61) in the multivariate models. The strongest effect of being inactive in terms of walking was calculated for Spain (OR 1.68, 95% CI 1.06–2.67). Interestingly, the effect of cycling points in the opposite direction in The Netherlands. Dutch participants with knee OA had a lower probability of being in the lowest cycling tertile (OR 0.57, 95% CI 0.34–0.96). That means that people with knee OA in the Netherlands cycle more often than people without knee OA do.

DISCUSSION

This international cross-sectional study has demonstrated that persons with knee OA, compared to persons without knee OA, are physically more inactive and are less likely to follow physical activity recommendations. However, the association between knee OA and physical activity substantially differs across countries and the type of physical activity considered.

We found a strong association between physical inactivity and knee OA in the UK and Spain. In these 2 countries, persons with knee OA walked less than individuals without knee OA. Daily walking activity accounted for one-third of the total physical activity score. This finding is in line with a global study comparing physical activity levels. In this study, 20% of the entire daily physical activity was derived from walking in all countries. This share increased to more than 30% in countries with substantial rates of high physical activity (21). In our study, persons with knee OA report less walking, which may decrease pain and disability. Reasons participants avoided walking could be pain that is associated with walking activity, as well as uncertainty about the role of moderate exercise and physical activity, along with the fear of continuing or worsening wear and tear within the joint (31).

On the other hand, we found no association of physical inactivity with knee OA in The Netherlands and Sweden. Participants with knee OA were overall as physically active as persons without knee OA. A detailed analysis revealed that older adults with knee OA even cycle more often in The Netherlands than individuals without knee OA. Cycling is a joint-friendly type of physical activity that is advised for persons with arthritis to meet physical activity recommendations (32,33). Persons with knee OA may cycle because cycling causes less pain, it is recommended by physicians, and the infrastructure facilitates this kind of physical activity. Since the 1970s, The Netherlands have served as an example of how continuous maintenance and improvement of cycling facilities can encourage inhabitants to engage in light exercise (34). Bauman et al (21) assumed that countries "with an infrastructure or culture that supports walking can achieve high levels of physical activity with lesser contribution from vigorous activity."

These country-specific associations between physical inactivity and OA support our assumption that the low level of physical activity in individuals with knee OA found in other studies (16,35) cannot be explained by individual or disease-specific factors only. Instead, public policies that promote physical activity (36) might have contributed to our results. Sweden, for instance, provides primary care advice by the general practitioner to populations at risk of chronic disease. Furthermore, communities can strongly influence people's levels of physical activity by shaping cultural attitudes towards physical activity as well as by offering social support. In Sweden, 74% of people agreed that "local sport clubs and other providers offer many opportunities for physical activity," compared to 54% in Italy (37). Finally, environmental conditions such as local climate have been found to affect pain perceptions in persons with OA (38), with a greater impact in Southern Europe. In summary, contextual factors seem to influence individuals' behavior when it comes to coping with their disease and influence whether they can build up a physically active lifestyle.

To our knowledge, the present study is the first that has compared physical activity in older persons with and without knee OA across countries. The assessments of physical activity and OA were standardized across countries using a validated physical activity questionnaire and the ACR criteria for clinical knee OA. The large size of the EPOSA cohort is a major strength of the present study. All cohorts were recruited from population samples and have been shown to be representative of the populations from which they were drawn. Each cohort was interviewed in different seasons to account for variations in physical activity levels (39) as well as severity of pain (40) over the year. Our findings accorded with patterns of physical activity across Europe derived from previous research. A north-south gradient in leisure time physical activity (41) was partly apparent in this study. Germany and the UK showed the most active population followed by Italy, Sweden and Spain. However, The Netherlands usually ranked highest in comparable analyses (20,42), while our study estimated the lowest activity score. Partly, the data collection phase may have contributed to that difference. In The Netherlands, the data collection mainly took place in the winter and spring season. An additional strength of our study is that in contrast to previous studies, which only assessed overall physical activity (35,43), we disaggregated the physical activity index score and calculated more detailed analysis for each type of physical activity. Thereby, we could show clearly that physical activities have to be disentangled and separated into their components, as demonstrated above.

Future health promotion activities on knee OA that incorporate these country-specific differences might be more effective. In order to invent targeted and substantial intervention programs, researchers first need to assess physical activity habits, which might be appreciably different in each country setting. For further research, we would recommend considering country- and context-specific activity patterns when designing interventions.

This study has some limitations. Self-reported physical activity may have been problematic due to the older participants having difficulties accurately recalling their daily activities (44). Questionnaires asking about a limited number of activities may not capture the activities in daily life in their entirety (45) or conversely may overestimate the duration of some daily activities. Accordingly, self-reports are likely to have a degree of measurement error (46) that is also reflected in our calculations by large confidence intervals. However, to our knowledge there is no evidence that physical activity misclassification would differ by OA status or any other demographic variable. If such a discrepancy was the case, results would be likely biased to the null (47). Accelerometers may be one suitable instrument in future studies that also indicate the intensity of each activity, which, in terms of knee OA, is an important indicator, besides the information from questionnaires.

One further limitation is that OA was not diagnosed with radiographic criteria but was defined based on the clinical ACR classification alone. However, to account for differences in radiographic and clinical OA, a subsample of the EPOSA cohort, who originally participated in the Hertfordshire Cohort Study, was closely investigated (48). The clinical definition was considered as correctly defining participants without OA (specificity of 91.5%). The majority of participants (66.1%) with clinical knee OA also had radiographic knee OA. On the other hand, far more participants were classified as having OA based on radiographic criteria than were identified with the clinical definition. This difference suggests that we underestimated the number of persons having radiographic OA but no clinical symptoms like pain. The aim of the EPOSA study was not to detect early structural joint cartilage changes but to find older persons with symptoms of OA, such as joint pain and functional limitations. In this setting, the clinical approach might reflect the burden of the condition more accurately. Furthermore, we do not have information about the history of previous knee injury or the exact compartment where knee OA is predominant. This knowledge would have provided additional valuable information on subgroups with even lower physical activity levels, but there is no reason this would cause an unequal distribution across the 6 countries participating in the study. The additional information would therefore only specify the effect of knee OA but would not explain country differences. In addition, our analyses did not distinguish between knee OA in 1 joint and the related pain levels. Joint pain is the dominant symptom of OA and consequently serves as 1 major component of the ACR definition. Another limitation could occur by dropping participants with joint replacements from our analyses. Studies showed that physical activity levels of people with joint replacements are neither comparable with persons without knee OA nor with persons with knee OA (35,49). Finally, causality cannot be inferred from cross-sectional data. Lower levels of physical activity could be a result not only of knee OA but could also be a consequence of other well known risk factors for the development of knee OA, such as obesity, bone deformities, or traumas (16,50).

This study contributes to public health efforts to provide evidence for contextual factors accounting for physical activity levels in individuals with knee OA. The application of standardized measures for knee OA and physical activity enabled us to compare the associations under study across all participating countries. We have shown that physical activity limitations differ across countries and the type of physical activity. The information presented in this article can greatly aid in informing public authorities about the value of an activity-supporting environment.

ACKNOWLEDGMENTS

The authors thank the EPOSA Study Group. T. Nikolaus (principal investigator), R. Peter, M. D. Denkinger, and F. Herbolsheimer (Germany); S. Maggi (principal investigator), S. Zambon, F. Limongi, M. Noale, and P. Siviero (Italy); D. J. H. Deeg (principal investigator), S. van der Pas, L. A. Schaap, N. M. van Schoor, and E. J. Timmermans (The Netherlands, coordinating center); Á. Otero (principal investigator), M. V. Castell, M. Sánchez-Martínez, and R. Quieipo (Spain); N. L. Pedersen (principal investigator) and R. Broumandi (Sweden); E. M. Dennison (principal investigator), C. Cooper, M. H. Edwards, and C. Parsons (UK).

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Herbolsheimer had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study conception and design. Herbolsheimer, Schaap, Edwards, Maggi, Otero, Timmermans, Denkinger, van der Pas, Dekker, Cooper, Dennison, van Schoor, Peter.
Acquisition of data. Herbolsheimer, Schaap, Edwards, Maggi, Otero, Timmermans, Denkinger, van der Pas, Dennison, van Schoor, Peter.
Analysis and interpretation of data. Herbolsheimer, Otero, Timmermans, Denkinger, van der Pas, Dekker, Cooper, Dennison, van Schoor, Peter.

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