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# The Impact of Self-Efficacy on Activity Limitations in Patients With Hip Osteoarthritis: Results From a Cross-Sectional Study

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**Objective.** Pain and activity limitations are the main health complaints in osteoarthritis. We explored pathways between pain and activity limitations in a chain mediation model that involved self-efficacy, physical activity behavior, and muscle function in patients with hip osteoarthritis not awaiting hip replacement.

**Methods.** We used cross-sectional, baseline data from a randomized controlled trial on 152 patients with clinical hip osteoarthritis according to the American College of Rheumatology not awaiting hip replacement. The associations between pain, self-efficacy, self-reported physical activity, muscle function (leg extensor power), and activity limitations (performance-based and self-reported activity limitation outcomes) were modeled using structural equation models.

**Results.** The effect of pain on performance-based activity limitation was fully mediated by self-efficacy, physical activity, and muscle function. Of the total effect of self-efficacy on performance-based activity limitation, the direct effect accounted for 63% (95% CI: 45%-82%), whereas the indirect effect via physical activity constituted 16% (95% CI: 1%-30%) and the indirect effect via muscle function constituted 21% (95% CI: 9%-32%). In contrast, physical activity and muscle function had no effect on self-reported activity limitations, whereas pain had a direct effect and an indirect effect mediated by self-efficacy.

**Conclusion.** Our results suggest that self-efficacy should be taken into consideration in prevention and treatment of activity limitations in patients with hip osteoarthritis not awaiting hip replacement. Coupling exercise with programs of self-efficacy enhancement could potentially increase the positive effects of exercise.

## INTRODUCTION

One in four persons develop symptomatic hip osteoarthritis (OA) in their lifetime (1), and activity limitations (ALs) are one of the primary health complaints (2). Problems with stair climbing, walking, getting in and out of the seated position, and activities that include outdoor mobility are frequently reported ALs in this patient group (2,3). In addition, the risk of death is higher compared with the general population, and the presence of walking disability is among the major risk factors (4). Therefore, it is of clinical relevance to explore the underlying mechanisms of AL in patients with hip OA.

Theoretical models have been developed to study the mechanisms underlying the associations between development of AL and identified risk factors in OA (5), for example, pain, avoidance of activity, and muscle weakness (6). Dekker et al (7) proposed

*the avoidance model* as a theoretical model to explain how behavioral mechanisms may cause AL sin patients with OA (5). According to this model, experience with pain during physical activity (PA) will lead to the expectation that further PA will cause greater pain, and this may result in avoidance of PA (8). In the short term, avoiding PA may reduce pain, but in the longer term, physical inactivity will result in a decrease of physical capacity, especially in muscle weakness, resulting in ALs (8). In patients with knee OA, validation studies of the avoidance model have shown strong evidence for an association between avoidance of activities and ALs, mediated by muscle weakness, and for an association between muscle weakness and ALs (5). However, it has been suggested that there may be more pathways and that other factors could be considered for inclusion in an avoidance model (8,9).

**Figure 1.** Our conceptualized model including self-efficacy. According to this model, patients with hip osteoarthritis experience pain during activity. Pain is hypothesized to have an impact on self-efficacy, and self-efficacy may influence how problems or difficult tasks (eg, physical activity) are perceived and consequently may influence the capability to be physically active. The amount of physical activity has an impact on muscle function, which again affects physical function.

Self-efficacy (SE), which is defined as "people's beliefs in their capabilities to organize and execute the courses of action required to produce given attainments" (10), may be involved in an alternative pathway (8,9). Low SE has been identified as a risk factor for worsening of ALs in patients with hip and knee OA (6), and a systematic review found strong evidence for the role of SE in predicting disability among patients with knee OA (11). It was argued that individuals with strong SE are deemed to view problems as tasks to be mastered and are able to recover more quickly from setbacks and disappointments (11). In contrast, those with a weak sense of SE believe that difficult tasks and situations are beyond their capabilities, and they consequently engage in avoidance coping (11). Thus, it is possible that patients with low SE may experience AL without a clear physical reason. Finally, at least in older persons, strong SE seems to attenuate functional decline in the face of diminished physical capacity (12,13).

SE has been predictive of self-reported activities of daily living disability but less predictive of performance-based outcomes (14). This could partly be because measures of SE include items that are not targeted to the behavior of interest, which would reduce the strength of the relationship. Consequently, it is important to choose a task-specific SE measure (14).

Rejeski and Focht (15) argued for the importance of SE, based on their research on the behavioral aspects of PA and functional decline in older persons, including those with knee OA. They suggested that physical symptoms (eg, pain) and SE should be incorporated into another influential model of disability, *the disablement process model*. The main pathway of this model includes four concepts: active pathology, impairment (eg, in muscle strength), functional limitations, and disability, all of which occur sequentially. Their position was that knee pain may either have a direct effect on functional limitations or an indirect effect via SE (15).

The aim of our study was to explore alternative pathways between pain and AL in a model that includes SE in patients with milder symptoms of hip OA. Our conceptualized model included pain during activity, SE, PA, muscle function, and AL (Figure 1). We hypothesized that pain will have an impact on SE and AL; SE may influence how problems or difficult tasks, such as PA, are perceived and consequently the capability to be physically active; the amount of PA will have impact on physical capacity, eg, muscle function, and SE will have the same or higher impact on AL in comparison with physical capacity.
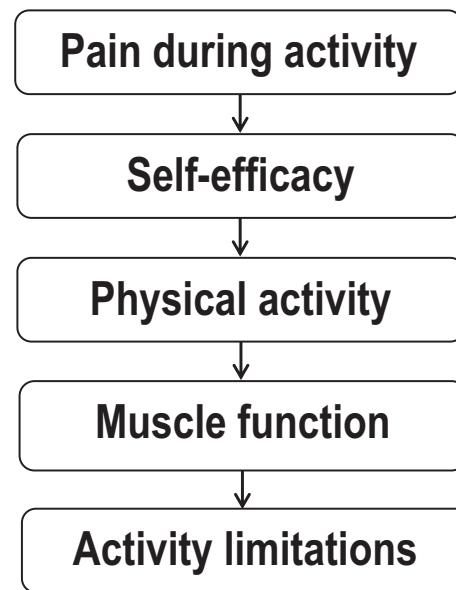
## PATIENTS AND METHODS

**Patients.** In this cross-sectional exploratory study, we used baseline data from a randomized controlled trial (ClinicalTrial.gov identifier: NCT01387867) (16), which included 152 home-dwelling people who were 60 years or older with clinical hip OA according to the American College of Rheumatology (17) and who were not awaiting total hip replacement. Exclusion criteria were: (a) symptomatic OA of the knee or the big toe, (b) other types of arthritis, (c) previous hip or knee replacement, (d) previous hip fracture, (e) comorbidity that prevented exercising, (f) treatment related to hip problems within the last 3 months, (g) inability to use public transportation, and (h) performing regular exercise/sports twice or more weekly (16). The patients were primarily recruited through advertisements in local newspapers. Of 648 potential study participants screened by phone, 308 did not meet the inclusion criteria, 129 declined to participate, and 59 were not included and randomized for other reasons, leaving 152 patients for the present study (16).

The study was conducted in accordance with the Declaration of Helsinki. Signed informed consent was obtained from all participants. The study was approved by the Research Ethics Committees for The Capital Region (H-C2009–042).

**Outcome variables included in the model.** The order of the individual measurements is shown below. All questionnaires had a 1-week recall time. Because PA is a multidimensional construct and thus difficult to measure (18), we used three

different outcome measures to describe PA as a latent variable, namely the Physical Activity Scale for the Elderly (PASE; total PA); leisure-time PA level (LPA), and vigorous PA (VPA). Similarly, AL is a complex concept, and because increasing evidence suggests that performance-based and self-reported measures capture different constructs of AL (19,20), we used both measures to describe AL as a latent variable, namely the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) subscale physical function (Wfunc), a timed stair-climb test, the 30-second chair stand test, and the 6-minute walk test.

*The Western Ontario and McMaster Universities Osteoarthritis Index.* WOMAC subscale pain during activity (Wpain) has a score from 0-20, best to worst; WOMAC subscale physical function (Wfunc) has a score range from 0-68, best to worst (21). These are criteria approved by the Outcome Measures in Rheumatology (OMERACT) committee and the Osteoarthritis Research Society International (OARSI). The latter is the proposed OMERACT-ARSI responder criteria for assessing physical function and AL in OA trials (22). Both scales are included in their original formats in the Hip Disability and Osteoarthritis Outcome Score questionnaire (23).

*Physical activity.* The PASE (24) has a score range from 0 to 400 or more, describing the lowest to highest PA level in occupational, household, and leisure activities. LPA consists of one question from the Copenhagen City Heart Study (25) (score levels: 1-4, where 1 = almost entirely sedentary, 2 = light PA for 2-4 h/wk, 3 = light PA >4 h/wk or more vigorous PA for 2-4 h/wk, 4 = more vigorous PA >4 h/wk or regular heavy exercise or competitive sports several times per week). VPA is one question from the Inter99 (26) regarding hours per week spent on PA that made the person breathless or sweaty (score levels: 0-5, where 0 = 0 h, 1 = 1/2 h, 2 = 1 h, 3 = 2-3 h, 4 = 4-6 h, and 5 = 7 h).

*Muscle function.* Leg extensor power (LEP) (force × velocity) measured with the Leg Extensor Power Rig (Queen's Medical Centre, Nottingham University, United Kingdom) (27) during a single explosive unilateral lower limb extension in the seated position

(28). We recorded the mean results of the two legs, and LEP was normalized to body weight because relative LEP gives a better indication of mobility in the performance of daily motor tasks (29).

*Task-specific SE.* In conjunction with a stair-climbing test, task-specific SE was measured (total score: 0-100, worst to best) (14). After a practice trial, the patients rated their level of certainty (11 levels from 0 = completely uncertain to 10 = completely certain) that they could complete the stair-climbing task 2, 4, 6, 8, and 10 times without stopping (14).

*Performance tests.* Tests used were a timed stair-climb test (TSC) (total time to ascend and descend a flight of 10 steps as fast as possible) (28), the 30-second chair stand test (30sCS) (total number of chair stands completed in 30 seconds) (28), and the 6-minute walk test (6MW) (total walking distance completed in 6 minutes) (28).

**Statistical analysis.** The study was explorative, and thus no a priori sample size calculation was performed. Outcome variables for males and females were compared by the two-sample Wilcoxon test. Bivariate associations were explored using the Spearman rank correlation. The relationships in the conceptual model (Figure 1) were examined using a structural equation model (SEM) (30). The model suggests a chain of relations—each outcome affecting subsequent outcomes—and the association between two of the outcomes consisting of a direct effect and indirect effects through one or more mediators (31). As a starting point, we considered the model by including direct effects between all outcomes as illustrated in the hypothesized model (Figure 2). Initially, before analyzing data by SEM, all associations between outcome variables and explanatory variables were explored by standard linear regression models to assess model assumptions of linearity, homogeneity of variances, and normality of residuals.

The PASE score was transformed by the logarithm to obtain a distribution closer to the normal. PA and ALs were considered
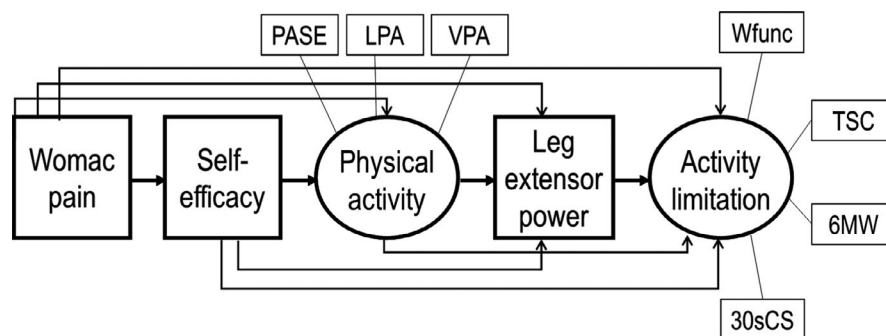
**Figure 2.** The hypothesized model including all the possible associations between pain during activity, self-efficacy, physical activity (PA), leg extensor power, and activity limitations. PA is considered a latent variable measured by vigorous physical activity (VPA), leisure-time PA level (LPA), and the Physical Activity Scale for the Elderly (PASE). Activity limitations are considered a latent variable measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical function subscale (Wfunc), the 30-second chair stand test (30sCS), the 6-minute walk test (6MW), and a timed stair-climb test (TSC).

latent variables, measured by VPA, LPA, and PASE, respectively, self-reported AL (Wfunc) and the performance-based measures of AL (30sCS, 6MW, TSC). All paths were modeled using linear regression analysis and were adjusted for age, gender, and body mass index. To set the measurement scale for each latent variable, one regression coefficient (factor loading) for the observed variables was fixed to 1. Choosing a regression coefficient of 1 for VPA and for the 30sCS test, results for the PA latent variable have to be interpreted on the VPA scale, and results for the AL latent variable have to be interpreted similarly on the 30sCS test scale.

The hypothesized model (Figure 2) was explored stepwise from left to right by first considering the submodel consisting of pain and SE, and then by considering submodels in which the remaining variables are added one-by-one from left to right, in each step eliminating associations not significant at the 10% level (corresponding to deletion of arrows from the figure). As goodness-of-fit criteria, we considered the likelihood ratio $\chi^2$ test, the root mean square error of approximation (RMSEA), the Bentler Comparative Fit Index (CFI), and the standardized root mean square residual (SRMR). Goodness of fit was considered fulfilled if the likelihood ratio test yielded a $p$ value above 0.05, the RMSEA was below 0.05, the CFI was above 0.95, and the SRMR was below 0.08 (30). When the models were not fulfilling these criteria, the models were revised using a forward search for additional arrows. The explained variation for AL was determined in the final model, and to assess the contribution of PA and LEP to the model, the explained variation was also determined in the models obtained by removing PA and LEP from the model.

All analyses were performed in R version 3.4.0 (32), and the SEM was analyzed using the lava package (33). $P$ values less than 0.05 were considered to represent significance.

## RESULTS

Characteristics of the study population are given for males and females separately in Table 1. Men had higher body mass index and physical and functional capacity compared with women, but they also had lower pain and higher SE. The majority (84%) of the patients were retired and well educated (53% had ≥13 years of education).

Estimated bivariate correlations from the initial explorative analyses between the various outcomes are given in Table 2.

In the analyses of the associations in the SEM (Figure 2), one person with a missing value for the PA variable VPA was excluded from the analysis. The steps from left to right in the hypothesized model (Figure 2) leading to the final SEM are described below.

**Self-efficacy.** SE was negatively associated with pain (Table 2). An increase of 1 point in the pain score corresponded to a decrease of 2.29 points (95% CI: 1.18 to 3.40) in SE ($p < 0.0001$).

**Physical activity.** In the bivariate analyses, none of the PA variables (VPA, LPA, and PASE) were associated with pain, whereas LPA and PASE were associated with SE (Table 2). In the SEM including pain, SE, and PA (latent variable) (the first three variables in Figure 2), there was no direct effect of pain on PA ($p = 0.59$), whereas SE had an effect on PA (an increase of 0.10 [95% CI: 0.03 to 0.17] on the VPA scale per 10 points on the SE scale, $p = 0.007$).

**Muscle function (LEP).** In the bivariate analyses, muscle function was associated with pain, SE, and PA through the VPA variable (Table 2). In the SEM (the first four variables in Figure 2), we found no direct effect of pain on muscle function ($p = 0.45$)

**Table 1.** Characteristics of the study population

| Characteristics | Male (n = 49) | Female (n = 103) | $p$ value |
|---|---|---|---|
| Age (y) | 71 (65-75) | 68 (65-73) | 0.16 |
| BMI (kg/m$^2$) | 27.6 (25.6-30.0) | 26.2 (23.6-29.2) | 0.03 |
| WOMAC pain (0-20)[a] | 4 (3-7) | 6 (3-8) | 0.04 |
| Self-efficacy | 86 (67-100) | 54 (36-80) | <0.001 |
| Physical activity[b] | | | |
| PASE (0-400) (p) | 111 (88.5-150) | 101 (78-156) | 0.25 |
| VPA (0-5) (l) | 2 (1-3) | 2 (0.8-3) | 0.74 |
| LPA (1-4) (l) | 3 (2-3) | 3 (2-3) | 0.9 |
| LEP (W/kg) | 1.9 (1.5-2.6) | 1.4 (1.1-1.7) | <0.001 |
| Activity limitations | | | |
| WOMAC PF (0-68)[a] | 14 (8-19.5) | 22 (14-29) | <0.001 |
| 30-second chair stand (number) | 15 (12.5-18.5) | 13 (10-16) | <0.001 |
| Timed stair climb (sec) | 8.7 (7.4-10.4) | 10.5 (8.8-11.8) | <0.001 |
| 6-minute walk (min) | 558.7 (486.1-637.7) | 504.6 (450.9-546.5) | <0.001 |

*Note.* Values are median and (interquartile range). The $p$ values are based on Wilcoxon two-sample test.
Abbreviations: BMI, body mass index; l, level; LEP, leg extensor power; LPA, level of physical activity questions from the Copenhagen City Heart Study; p, points; PASE, Physical Activity Scale for the Elderly; PF, subscale physical function; VPA, vigorous physical activity; WOMAC, Western Ontario and McMaster Osteoarthritis Index.
[a] On the WOMAC scale, 0 is the best.
[b] For the physical activity category, low values represent worst scores.

**Table 2.** The correlations (Spearman) between the various outcomes

|  | Pain | SE | VPA | LPA | PASE | LEP | Wfunc | 30sCS | 6MW | TSC |
|---|---|---|---|---|---|---|---|---|---|---|
| Pain | *** 1.00 |  |  |  |  |  |  |  |  |  |
| SE | *** −0.31 | *** 1.00 |  |  |  |  |  |  |  |  |
| VPA | −0.01 | * 1.16 | *** 1.00 |  |  |  |  |  |  |  |
| LPA | −0.15 | *** 0.25 | *** 0.30 | *** 1.00 |  |  |  |  |  |  |
| PASE | −0.06 | *** 0.26 | *** 0.30 | *** 0.28 | *** 1.00 |  |  |  |  |  |
| LEP | *** −0.23 | *** 0.51 | *** 0.23 | 0.06 | 0.11 | *** 1.00 |  |  |  |  |
| Wfunc | *** 0.68 | *** −0.47 | −0.01 | ** −0.22 | −0.09 | *** −0.34 | *** 1.00 |  |  |  |
| 30sCS | *** −0.23 | *** 0.51 | ** 0.21 | *** 0.23 | ** 0.21 | *** 0.57 | *** −0.44 | *** 1.00 |  |  |
| 6MW | *** −0.28 | *** 0.68 | ** 0.21 | ** 0.23 | *** 0.24 | *** 0.65 | *** −0.46 | *** 0.71 | *** 1.00 |  |
| TSC | *** 0.28 | *** −0.66 | *** −0.29 | ** −0.22 | *** −0.26 | *** −0.64 | *** 0.38 | *** −0.71 | *** −0.83 | *** 1.00 |

Abbreviations: 30sCS, 30-second chair stand test; 6MW, the 6-minute walk test; LPA, physical activity level; PASE, Physical Activity Scale for the Elderly; SE, self-efficacy; TSC, a timed stair-climb test; VPA, vigorous physical activity; Wfunc, the Western Ontario and McMaster Universities Osteoarthritis Index subscale physical function.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

and furthermore no association between PA and muscle function ($p = 0.46$), whereas there was a direct effect of SE on muscle function (an increase of 0.07 W/kg [95% CI: 0.03 to 0.10] per 10 points on the SE scale, $p < 0.0001$). Omitting the arrow (non-significant association) between PA and muscle function from the hypothesized model (Figure 2), a multiple mediator model is obtained instead of the initially proposed chain mediation model.

**Activity limitations.** In the bivariate analyses, the performance-based AL outcomes (30sCS, 6MW, TSC) were associated with all other outcomes, whereas self-reported ALs (Wfunc) were associated with all but the PA outcomes PASE and VPA. Taking as a starting point the multiple mediator model described above, there was a direct effect of pain ($p = 0.02$), SE ($p < 0.0001$), PA ($p = 0.01$), and muscle function ($p < 0.0001$) on ALs. However, the model did not fit to the data according to the goodness-of-fit criteria ($x^2$ $p < 0.0001$, RMSEA = 0.12, CFI = 0.86, SRMR = 0.07). Performing a forward search for additional arrows, we found an association between pain and self-reported AL (Wfunc) corresponding to item bias (differential item functioning) being present. Adding the arrow from pain to self-reported AL (Wfunc) to the model, the direct effect of pain on AL could be removed from the model ($p = 0.11$) (Figure 3). Repeating the forward search, no further arrows were identified, and the goodness of fit was improved ($x^2$ $p = 0.02$, RMSEA = 0.06, CFI = 0.97, SRMR = 0.04). The resulting model and the estimated relationships are illustrated in Figure 3.

**Final models.** As illustrated by the item bias of self-reported ALs (Wfunc), performance-based and self-reported ALs reflect different aspects. We therefore decided to consider separate models for performance-based and self-reported ALs. This procedure resulted in the final models depicted in Figure 4A (performance-based ALs) and Figure 4B (self-reported ALs). Note that PA and muscle function were removed from the model for self-reported AL as no effect of any of these two variables on self-reported AL were found ($p = 0.68$ resp. $p = 0.58$). The resulting model for self-reported AL is thus a standard linear regression analysis of Wfunc on SE adjusted for pain (Figure 4B). Goodness of fit according to the $x^2$ test and RMSEA could not be assessed for the model for self-reported AL as no further arrows could be added, but for the model for performance-based ALs, the model criteria were fulfilled ($x2$ $p = 0.14$, RMSEA = 0.04, CFI = 0.98, SRMR = 0.03; see Figure 4A).

**Mediation.** As illustrated in Figure 4A, the effect of pain on performance-based ALs is fully mediated by SE, PA, and muscle function. The total effect of SE corresponding to a difference of 10 points is 0.64 chair stands (95% CI: 0.46 to 0.82) of which 0.41 chair stands (95% CI: 0.23 to 0.58, $p < 0.0001$) constitutes the direct effect, 0.10 chair stands (95% CI: 0.01 to 0.20, $p = 0.04$) the indirect effect via PA, and 0.13 chair stands (95% CI: 0.05 to 0.241, $p = 0.001$) the indirect effect via muscle function. Thus, the direct effect accounts for 63% (95% CI: 45% to 82%) of the total effect of SE on ALs, the indirect effect via PA for 16% (95% CI: 1% to 30%), and the indirect effect via muscle function for 21% (95% CI: 9% to 32%). The SEM explains 74% of the variation in performance-based AL, whereas the explained variation for SE alone (obtained from the SEM omitting PA and muscle function) is 60%.

The association between SE and self-reported AL was not found to be mediated by PA and muscle function. Adjusted for
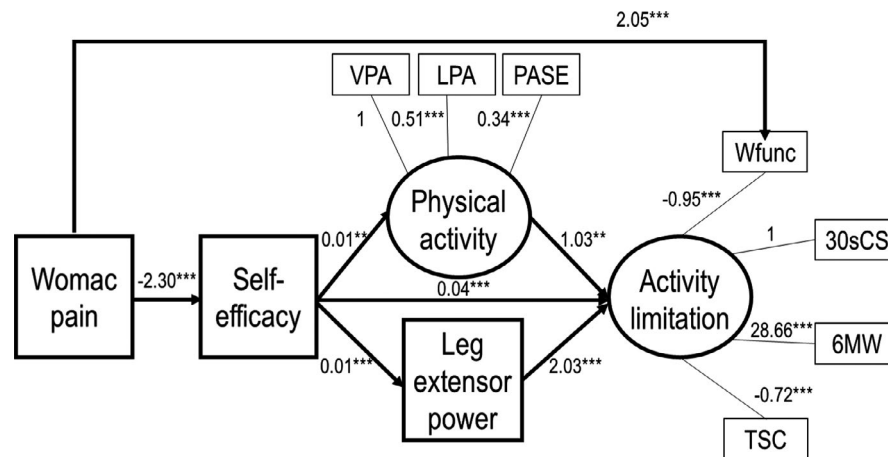
**Figure 3.** The final model based on the hypothesized model (Figure 2). Associations not significant at the 10% level have been removed from the hypothesized model. There was an additional association between pain and self-reported activity limitation (Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC] physical function subscale [Wfunc]) corresponding to item bias (differential item functioning) being present. **$p < 0.01$, ***$p < 0.001$. Abbreviations: 30sCS, 30-second chair-stand test; 6MW, 6-minute walk test; LPA, leisure-time PA level; TSC, timed stair-climb test; VPA, vigorous physical activity.

pain, the effect of SE corresponding to a difference of 10 points is a decrease of 0.74 points in self-reported AL (95% CI: 0.18 to 1.29, $p = 0.01$) (Figure 4B). Pain and SE explain 51% of the variation in self-reported ALs.

## DISCUSSION

To get insight into the possible complex underlying mechanisms of AL in hip OA, we explored the pathways between pain and AL in a model that involves SE (Figure 1) in patients with

symptomatic hip OA not awaiting hip replacement. The main findings of the analyses are summarized as follows: to explain the relationships between all the outcomes, we initially expected a chain mediation model (Figure 2), but the empirically driven analyses instead suggested a multiple mediator model (Figure 3). Performance-based ALs and self-reported ALs demonstrated reflections of different aspects of AL, and consequently we suggested considering performance-based ALs and self-reported ALs separately. The effect of pain on performance-based ALs was fully mediated by SE, PA, and muscle function (Figure 4A).
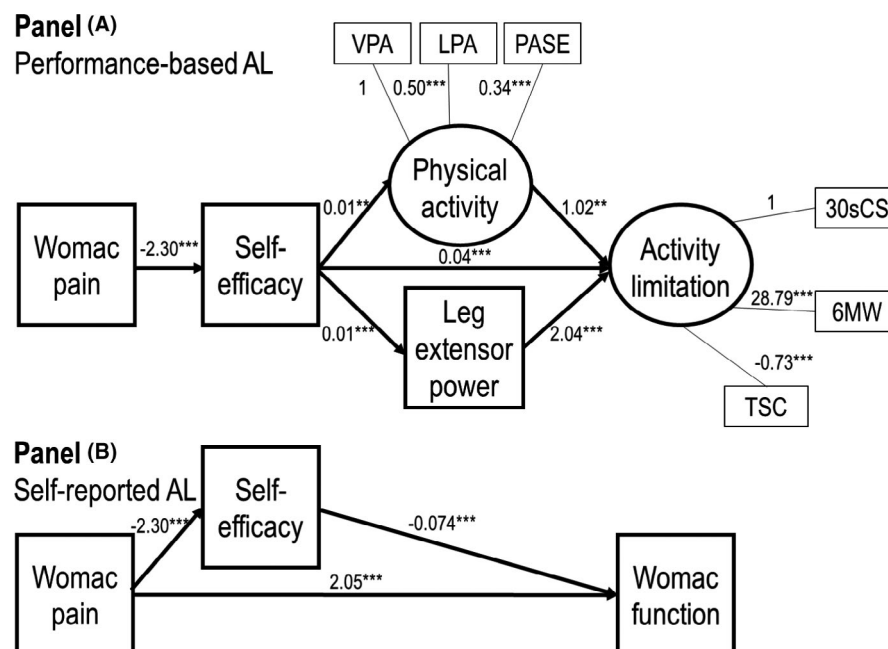


**Figure 4.** **A**, The final model for performance-based activity limitations. **B**, The final model for self-reported activity limitations (ALs). **$p < 0.01$, ***$p < 0.001$. Abbreviations: 30sCS, 30-second chair-stand test; 6MW, 6-minute walk test; TSC, a timed stair-climb test; Womac function, Western Ontario and McMaster Universities Osteoarthritis Index subscale physical function.

The direct effect of SE accounted for most of the effect of SE on performance-based ALs (63%), whereas the indirect effect via PA constituted 16%, and the indirect effect via muscle function constituted 21% of the effect. Similarly, most of the variation in performance-based AL was explained by SE, as SE in combination with PA and muscle function explained 74% of the variation, whereas SE alone explained 60%. In contrast to the analysis of performance-based ALs, our analysis of self-reported ALs did not find an association with PA and muscle function, thus resulting in a single mediator model in which pain has a direct effect on self-reported AL and an indirect effect mediated by SE. Pain and SE explained 51% of the variation in self-reported ALs.

Few studies have investigated by which mechanisms risk factors cause ALs in patients with OA. Seven studies have examined the validity of the avoidance model in patients with knee OA or knee pain (5), and they have all used either self-reported or performance-based AL, with the exception of one study (9). In concordance with our study, Holla et al (9) considered AL as a latent variable measured by self-reported AL (Wfunc) and performance-based measures of AL (a timed stair-climbing test). However, they did not report item bias of self-reported AL (Wfunc) as found in our study. Our results are in line with the growing evidence that suggests that performance-based measures capture a different construct of AL than self-reported measures (19,20). Furthermore, the WOMAC subscale pain has been shown to be highly related to the subscale physical function; this lack of discriminant construct validity is one of the major criticisms specifically related to the latter subscale (20,34). Finally, not finding an effect of PA and muscle function on self-reported ALs in our study is in line with previously published results in patients with hip and knee OA showing that self-reported ALs compared with performance-based ALs are largely dependent on pain and to a lesser extent on range of joint motion and muscle strength (35).

PA is a complex behavior and thus challenging to measure (18), which may have influenced the result from the SEM showing no association between PA and muscle function. To measure PA, we used questionnaires that are susceptible to recall bias and may have over- or underestimated the participants' PA levels. In addition, older persons are more likely to engage in light- to moderate-intensity PA, which is the most difficult type of activity to assess by questionnaire (18). Although not directly comparable, our results are in line with findings from a systematic review on the evidence for the avoidance model, which found no association between avoidance of activities and muscle weakness in hip OA (5).

We explored pathways between pain and AL in a model that involves SE based on the research from Rejeski and Focht (15) and suggests that pain may either have a direct effect on ALs or an indirect effect via SE. Our results showed that in patients with hip OA not awaiting hip replacement, the effect of pain on self-reported and performance-based AL is fully mediated by SE and that pain only has a direct effect on self-reported AL.

We could not find any study that has investigated the impact of SE on AL in patients with hip OA. Nevertheless, in line with our results, Harrison (36) reported that in patients with knee OA, SE was an important factor affecting both self-reported AL (Wfunc) and performance-based AL (ie, walking, stair climbing, and chair stands) and that pain was related to self-reported AL but not to performance-based AL. However, our results are not directly comparable to the numbers reported by Harrison, as she reports standardized coefficients, which are known to be sample specific and unstable across different samples because of differences in the variances of the variables (30). In support of our results, Maly et al (37) found that in patients with knee OA, SE fully mediated the effects of age, stiffness, and pain on walking performance (6MW). The effects of muscle strength were only partially mediated by SE. The authors specified that their participants were strong and that SE is most influential in persons challenged by muscular weakness, so a task requiring greater strength like stair climbing could have yielded a different finding (37).

In contrast to our study, Harrison (36) and Maly et al (37) measured functional SE with the widely used physical function subscale of the Arthritis Self-Efficacy Scale that was developed to measure patients' arthritis-specific SE, or the patients' beliefs that they could independently perform daily activities involving upper and lower extremities (38,39). However, this subscale might have a ceiling effect in our target group because six of the nine questions address upper-extremity activities (eg, SE regarding buttoning a shirt and cutting pieces of meat) that would cause little or no problem for persons with lower-extremity OA only. Consequently we decided to measure SE as a task-specific SE in conjunction with the stair-climbing test developed by Rejeski et al (14), who found that SE appeared to be most important to functional decline when older adults with knee pain were challenged by muscular weakness of the lower extremities.

The strength of our study is that we explored the process or mechanism by which risk factors for ALs affect one another in a model that involves SE. To meet some of the criticism of performance-based measures of AL regarding narrow content validity, we used a set of recommended tests (40) that captured the main problems in patients with hip OA, such as getting in and out of the seated position, stair climbing, and walking (2,3). However, the study has several limitations that need to be addressed. The cross-sectional design of this study is an important limitation because causality cannot be inferred with this design. Thus, it cannot be ruled out, for example, that performance-based AL leads to reduced SE. Therefore, our results need to be confirmed in a longitudinal study. In addition, we did not perform a power calculation prior to the analysis, but there are examples of very small studies analyzed by SEMs with several latent variables (41,42). Our sample size was not large considering the number of parameters needed in our models, and with a larger sample size, we might have been able to identify all relationships in our conceptual model. Finally, our patients were selected because they

signed up for an exercise intervention study. They were motivated to become more physically active, which may indicate that their sense of SE was probably not weak. Thus, our results cannot with certainty be generalized to the total group of patients with hip OA.

In regard to daily clinical practice, our results suggest that besides PA and muscle function, SE could be considered an important part of the complex underlying mechanisms of AL in patients with hip OA not awaiting hip replacement. It is possible to design a rehabilitation program to prevent or treat low SE (43). Patients may need a functional assessment and information of their true risk for harming themselves through certain activities to help them challenge their beliefs regarding how much activity restriction is appropriate given their actual physical limitations (43). Many patients find that when they challenge their beliefs and increase their activity, the pain does not necessarily increase and they may even feel better (44).

To summarize, our cross-sectional analyses suggested two different explanations of the associations between pain, SE, PA, muscle function, and ALs in patients with hip OA. The effect of pain on performance-based ALs was fully mediated by SE, PA, and muscle function, and most of the variation was explained by SE. In contrast, pain had a direct effect on self-reported ALs and an indirect effect mediated by SE, whereas PA and muscle function were not associated with self-reported ALs. Our results need to be confirmed in a longitudinal study but point to the importance of assessing SE in prevention and rehabilitation of ALs in persons with hip OA.

## ACKNOWLEDGMENT

## AUTHOR CONTRIBUTIONS

All the authors were involved in drafting the article and revising it critically for important intellectual content, and they have read the final version and agree with its content.
**Study conception and design.** Bieler, Beyer, Rosthøj.
**Acquisition of data.** Bieler, Beyer.
**Analysis and interpretation of data.** Bieler, Anderson, Beyer, Rosthøj.

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