Published in final edited form as:

Res Nurs Health. 2011 June ; 34(3): 218–227. doi:10.1002/nur.20432.

Non-Verbal Cues to Osteoarthritic Knee and/or Hip Pain in Elders

Pao-Feng Tsai, RN, PhD[Associate Professor],

Alice An-Loh Sun Endowed Professorship in Geriatric Nursing, College of Nursing, University of Arkansas for Medical Sciences, 4301 West Markham St. Slot 529, Little Rock, Arkansas 72205, Phone: (501) 296-1999, Fax: (501) 686-8350

Yong-Fang Kuo, PhD[Associate Professor],

Sealy Center on Aging, Department of Preventive Medicine and Community Health, The University of Texas Medical Branch

Cornelia Beck, RN, PhD, FAAN[Professor],

Department of Geriatrics, College of Medicine, University of Arkansas for Medical Sciences

Kathy C. Richards, RN, PhD, FAAN[Professor],

University of Pennsylvania, School of Nursing

Kevin M. Means, MD[Professor],

Department of Physical Medicine and Rehabilitation, the University of Arkansas for Medical Sciences

Barbara L. Pate, RN, PhD[Clinical Instructor], and

College of Nursing, University of Arkansas for Medical Sciences

Francis J. Keefe[Professor]

Department of Psychiatry and Behavioral Science, Duke University Medical Center

Pao-Feng Tsai: tsaipafeng@uams.edu

Abstract

Behavioral cues are believed to be useful to identify pain among elders who may be experiencing pain but unable to express it. To examine this assumption, we recruited 192 elders who could verbally express pain to determine whether regression models combining behavioral cues (motor and gait patterns) predicted verbal pain reports. In the best model, age ($p < .01$) and subscales that measured guarding ($p < .001$) and joint flexion ($p < .01$) motor patterns were significant predictors of verbal pain reports. The receiver operating characteristic curve indicated that the best cutoff for predictive probability was 40–44%, with a fair to good C statistic of .78 ($SD = 0.04$). With a 40% cutoff, sensitivity and specificity were 71.6% and 71.0%, respectively. The investigators concluded that the final model could serve as a building block for the development of a tool using behavioral cues to identify elders' pain.

Keywords

aging; pain; arthritis; Alzheimer's disease; non-verbal cues; cognitive impairment

Osteoarthritis (OA) affects 21 million people in the United States (National Institutes of Health, 2007); the majority of those diagnosed with OA are elders, individuals aged 60 and

older. With unrelieved pain, elders with OA of the knee or hip may avoid lower extremity activities such as walking, doing house chores, or shopping. As a result, they may become sedentary. Indeed, knee and hip pain from OA are the leading causes of disability in elders (O'Connor, 2006). If OA pain is identified and treated, however, elders can maintain their daily activities and delay declines in function.

Little attention has been paid to chronic pain, including OA pain, in the elderly. One problem is that elders with chronic OA pain often choose not to communicate the occurrence or degree of their pain (Miaskowski, 2000). Even if they report the pain, they tend to minimize the level of pain, and thus healthcare providers may not see it as important (Miaskowski, 2000). Healthcare providers may pay even less attention to elders who are unable to express their pain verbally, such as those with severe cognitive impairment (Cornali, Franzoni, Gatti, & Trabucchi, 2006; Reynolds, Hanson, Devellis, Henderson, & Steinhauser, 2008). Thus, although self-report is the gold standard for information about pain (Hadjistavropoulos & Craig, 2004), an alternative to verbal reports is needed to identify OA knee and/or hip pain in elders who are unwilling or unable to verbally express their pain.

People who experience pain may show a range of behaviors that communicate the pain, including para-verbal sounds (such as sighs), body posturing and gesturing, displays of functional limitations, and behaviors to reduce the pain, such as use of pain medication (Fordyce, 1976). Keefe, Williams, and Smith (2001) found that people with knee pain from OA were more likely to experience pain when moving. Based on this observation, Keefe et al. (2001) developed an OA knee-specific pain behavior observation method. When the method was tested in elders without cognitive impairment, behavior observational scores were significantly related to verbal reports of pain ($r = .46, p < .001$; Keefe et al., 1987). Other investigators (Bejek, Paroczai, Illyes, & Kiss, 2006) found that patients with knee or hip OA showed motor patterns similar to those reported by Keefe et al. (2001). Thus, Keefe's observation method for knee pain should be useful for observing both OA knee and hip pain (F. J. Keefe, personal communication). Keefe's method predicted only 21% of the variance in OA knee pain, however (Keefe et al., 1987); thus additional behavioral indicators are needed to predict OA knee and/or hip pain.

A potential addition to Keefe's motor indicators includes disturbances of gait. Patients with severe OA knee or hip pain tend to show gait disturbances while walking (Asthen, Deluzio, Caldwell, Dunbar, & Hubley-Kozey, 2008; Mejjad et al., 2000). Elders with OA of the knee or hip reduce the loading forces on their painful joint, stand straighter, and spend less time planting their feet on the ground. In addition, they spend less time standing on the painful knee or hip and reduce the force placed on the ground and the corresponding ground reaction force transmitted back to the limb (Bejek et al., 2006; McCrory, White, & Lifeso, 2001). Thus, examining a combination of motor and gait patterns may improve the prediction of OA knee and/or hip pain.

This study therefore extended Keefe's work on motor patterns by adding gait patterns as a behavioral cue of elders' OA knee and/or hip pain. In addition, because age, sex, race, and body mass index (BMI) have been associated with OA or knee pain complaints (Allen et al., 2010; Paradowski, Bergman, Sunden-Lundius, Lohmander, & Roos, 2006; Tukker, Visscher, & Picavet, 2009), and BMI also was associated with impaired mobility in people with musculoskeletal complaints (Tukker et al., 2009), age, sex, race, and BMI were identified as potential covariates.

The study was designed to determine whether motor and gait patterns predicted knee or hip pain in elders who could verbally report their pain. We recruited only elders who were able to verbally express pain, on the assumption that those able to express pain also would show

behavioral indicators that could be useful in future studies to identify pain in elders unable to express pain. Research questions were: (a) what are the sensitivity and specificity of a pain assessment model combining summary scores on motor patterns and summary scores on gait patterns to predict verbal reports of pain by elders, controlling for age, sex, race, and BMI? and (b) what is the best model for predicting verbal reports of pain in elders with OA pain of the hip and/or knee?

Methods

Study Sites and Participants

One hundred ninety two community-dwelling elders who were able to express pain verbally participated in the study during May 2004–April 2007. Elders were recruited from the Memory Research Center (MRC), Senior Health Clinic, and university hospital of the University of Arkansas for Medical Sciences, retirement apartments, and senior centers. Elders with and without diagnosed OA of the knee or hip were enrolled. Approximately 46% of the sample had no OA of the knee/hip, and 54% had OA of the knee/hip. Elders in the OA group were selected using the following criteria: (a) English-speaking, (b) age 60 and above, (c) self-report of an OA knee or hip diagnosis, (d) self-report of knee or hip pain, (e) ambulatory, including using a walker or a cane, and (f) Mini-Mental State Exam (MMSE) score of 18 or above.

The MMSE, a 30-item global cognitive measure (Folstein, Folstein, & McHugh, 1975), was used to screen out elders with moderate or severe dementia. Agreements between MMSE and Clinical Dementia Ratings have been reported as .62–.76 ($p < .001$) for the categories of mild, moderate and severe dementia (Perneckzy et al., 2006). The MMSE also has shown good internal consistency reliabilities ($r = .75-.76$; Lopez, Charter, Mostafavi, Nibut, & Smith, 2005). Scores of 0–9, 10–17, 18–23, and 24–30 are considered severe, moderate, mild and no dementia, respectively (Folstein et al., 1975). Participants in this study had MMSE scores of 18–30, indicating no or mild dementia. Elders with MMSE 24–30 signed their own consent. Because scores of 18–23 are considered to reflect mild dementia, elders with an MMSE score in this range were required to have a family member or guardian co-sign the consent.

Elders in the OA group were excluded if they had (a) diabetic neuropathy; (b) persistent, severe low back pain; (c) other severe painful conditions of the lower extremities, such as foot pain, fracture, or painful skin lesions from other illnesses; (d) arthroscopic surgery, or a total knee or total hip replacement within the last year; (e) leg length discrepancy greater than 1/2 inch; (f) one or more falls within the last 3 months; (g) Parkinsonism; or (h) a history of vertigo during the last month. These exclusion criteria were based on self-report.

The same inclusion and exclusion criteria were used for the non-OA group, except they did not have knee or hip pain and an OA diagnosis. Because they were unlikely to have knee/hip pain, elders in the non-OA knee/hip group served as the reference group. We collected the same data from elders without OA as from elders with OA.

Procedure

Memory Research Center participants had signed an agreement with the MRC to be contacted about volunteering for future research. A staff member from the MRC made a telephone call to potential participants and asked for their permission to have project staff member contact them. If elders agreed, they were telephoned by a project research assistant (RA) who completed the initial screening and learned which times of day elders experienced the most pain. For non-MRC participants, a recruitment flyer was posted in facilities, or the facility staff or an RA distributed flyers to elders or their family members asking for

permission to contact the elderly individual. If signed permission was granted, elders were telephoned by the RA to conduct initial screening and learn which times of days they experienced the most pain. Elders were then scheduled for consenting, face-to-face interviews, and videotaping of pain-related behaviors at a time when the elders experienced the most pain. The RA instructed the elders to bring their pain medications to the study site and take them as needed or as prescribed after the interview and videotaping procedure. Elders were rescheduled if they had to take the pain medication before the interview and videotaping. No one in our study, however, took pain medication before the interview and videotaping session. The Committee on the Conduct of Human Research of the University of Arkansas for Medical Sciences approved the study.

Variables

Dependent variable—Pain was measured by the Verbal Descriptor Scale (VDS), which can be used successfully with elders who have less than a high school education (Herr, Spratt, Mobily, & Richardson, 2004). The VDS, with 7 choices from *no pain* to *pain as bad as it can be*, is considered the best verbal pain report tool for the elderly (Horgas, 2007). Scores on the VDS have been significantly and strongly associated with other commonly used pain measures, such as the Numeric Rating Scale ($r = .91, p < .001$), the Horizontal-Visual Analogue Scale ($r = .88, p < .001$), and the Pain Thermometer ($r = 1.00, p < .001$; Herr et al., 2004). Elders have rated VDS as preferable to other pain scales (Herr & Mobily, 1993). Before we administered the VDS, we asked elders to perform the following activities: rise from a chair with arms, walk about 10 feet and come back, and sit down in the same chair. Then we inquired about the intensity of their current pain, using the VDS scale. Scores were dichotomized for logistic regression as 0 = *no pain*; 1–6 = *pain*.

Predictors—Predictors were defined as pain cues requiring no verbal report. Motor and gait patterns were the major potential predictors examined.

Motor patterns: The behavioral observation method developed by Keefe et al. (2001) was used to score motor patterns seen in elders with or without OA. As reported by Keefe et al. (1987), the concurrent validity of the behavioral observation method was evidenced by a moderate correlation with the patient's self-report of pain ($r = .46, p < .001$). Patients who reported OA knee pain exhibited significantly more pain behaviors than patients who did not report OA knee pain ($t = 2.82, p < .01$), and rheumatologists' pain ratings were significantly correlated with the number of pain behaviors ($r = .65, p < .01$), indicating construct validity (Keefe et al., 1987).

Although Keefe's observational method was designed for patients with OA of the knee, after consultation with Dr. Keefe, we revised the coding system to make it appropriate for people with both knee and hip pain. In the revised observational method, five behaviors were included: (a) guarding (abnormally slow, stiff, interrupted or rigid movements while moving from one position to another or while walking), (b) active rubbing of the knee or hip (hands moving to or holding the affected knee or hip), (c) rigidity (excessive stiffness of the affected knee or hip during activities other than walking), (d) unloading the joint (shifting weight from one leg to the other while standing), and (e) joint flexion (flexing the affected knee or hip while in a static position).

In our study, elderly participants were videotaped for 10 minutes during which they engaged in a set of standard, timed activities--a series of 1 and 2- minute periods of sitting, walking, reclining, and standing. Each 10-minute videotape was then divided into 20 intervals for rating. Each interval consisted of 20 seconds of observing time and 10 seconds of recording time for a total of 30 seconds per interval. Participants received a maximum of 1 point for

each pain behavior observed during each of the 20 intervals. If elders displayed the same behavior more than once during an interval, the behavior was counted only once. Thus, the maximum score for each interval was 5. We used the sum of all five behavior scores (guarding, active rubbing of the knee, rigidity, unloading the joints, and joint flexion; i.e., the total number of pain behaviors), for analysis in initial models and the five individual behavior scores for analysis in the best model. Higher scores indicated more motor patterns reflecting pain. The maximum score possible was 100, but scores rarely exceeded 15 in our study. One RA who was trained by Dr. Keefe scored all the videotapes. The RA had an initial inter-rater agreement of 98% and Cohen's kappa reliability of .82 with Dr. Keefe's research staff for five training observations. The RA achieved an average of 99% agreement and .89 Cohen's kappa reliability with Dr. Keefe's staff for eight observations during the study.

Gait patterns: The gait subscale of the Tinetti Index (1986) was used to measure gait patterns. This performance-oriented assessment of mobility does not require equipment and is relatively easy to administer. The rater observes for indications of gait disturbances while the elder walks on a 6.1 meter floor mat at his/her "usual" pace, and returns at a "rapid, but safe" pace. These activities elicit problematic gait patterns.

The Tinetti Index scores have been positively correlated with walking speed ($r = 0.78-.79$; Gray et al., 2009). Inter-rater reliability between raters in other studies has ranged from 88% to 97% (Kegelmeyer, Kloos, Thomas, & Kostyk, 2007; Sterke, Huisman, van Beeck, Looman, & van der Cammen, 2010). The gait subscale includes 10 gait parameters. Elders receive a score of 1 for 8 parameters (initiation, walk stance, pass opposite foot-right and left, clear floor-right and left, step symmetry, and step continuity) and a score of 2 for 2 parameters (path and trunk) if they do not show impairments, such as hesitancy to start walking, heels apart rather than together, inadequate step length and height, stopping or discontinuity between steps, deviated path, and trunk sway while walking. Thus the score range is 0–12. Higher scores indicate a better gait. One RA gave instructions to the elders and videotaped their gait patterns. Two trained RAs later observed the videotape and recorded the results on the gait subscale of the Tinetti Index. The RAs had average inter-rater agreements with co-author Dr. Means's ratings of 94% and 90% during the study.

Covariates—Data on the potential covariates of age, sex, race, and BMI were also collected. Weight in pounds and height in inches were converted to a BMI.

Analysis

To determine the sensitivity and specificity of the pain assessment and identify the best model for predicting verbal reports of pain, three logistical regression models were built using verbal reports of pain as the dependent variable and motor and gait patterns as the major predictors, controlling for potential covariates. Sensitivity and specificity were calculated from four values: true positives (TP), the number of elders the model correctly predicted as having pain; false positives (FP), the number of elders with no pain whom the model falsely predicted as having pain; true negatives (TN), the number of elders the model correctly predicted as having no pain; and false negatives (FN), the number of elders with pain whom the model wrongly predicted as having no pain. The sensitivity of a model was the proportion of elders with pain who were correctly predicted to have pain $[TP/(TP + FN)]$. Specificity was the proportion of elders without pain who were correctly predicted as being pain free $[TN/(TN + FP)]$.

The receiver operating characteristic (ROC) curve (Gönen, 2007) was generated from the last model (Model 3) to examine the trade-off between sensitivity and specificity. The ROC

curve is a plot of sensitivity against 1 minus specificity pairs. If the discrimination of the model is perfect, sensitivity is 100% and 1 minus specificity is zero. Therefore, the closer the plot to the upper left corner of the curve, the greater the predictive probability of the model. The area under the curve (C statistic) provided the measure of a model's ability to distinguish between elders who reported having pain and those who reported having no pain, with a scale of .5 representing discrimination no better than chance and 1 representing perfect discrimination. The sensitivity, specificity, positive predictive value [TP/(TP + FP)] and negative predictive value [TN/(TN + FN)] associated with different cutoffs on predictability from the ROC curve were also examined. The variance explained by the final model was calculated using generalized R-square.

Results

The average age of the 192 participants was 73.5 years ($SD = 7.7$). Seventy-seven percent were women, and 85% were white. The average MMSE score was 28.7 ($SD = 1.8$) indicating that the majority of participants had no dementia. The sample's average score on gait patterns was 11.2 ($SD = 1.1$); the two groups had similar scores (pain group 11.2 [$SD = 1.2$]; no pain group 11.3 [$SD = 1.0$]). Their average motor score was 3.9 ($SD = 3.7$); elders with OA pain had an average motor score of 5.4 ($SD = 3.6$) and elders without pain had an average score of 2.2 ($SD = 2.9$; see Table 1). Among those with OA knee/hip pain ($n = 104$, 54%), 45, 28, and 31, respectively, had knee, hip, or both knee and hip pain. Their pain level, measured by the VDS, ranged from 0–4, with a mean of 1.5 ($SD = 1.3$). Although we inquired about their most painful time during a typical day and scheduled the elders to come in during this time of the day, a few of them came to the study laboratory without pain as measured by the VDS or without pain severe enough for them to report at that moment.

The first research question was posed to address the sensitivity and specificity of a pain assessment model combining summary scores on motor patterns and summary scores on gait patterns to predict verbal reports of pain by elders, controlling for age, sex, race, and BMI. Findings from the logistic regression indicated that the combination of gait and motor patterns as well as the four covariates (age, sex, race, and BMI) had a sensitivity of 60.5% and a specificity of 80.4% in predicting verbal reports of pain. The sensitivity was marginally acceptable, but the specificity was clearly acceptable (see Table 2, Model 1). Only motor patterns ($p < .001$) and age ($p < .05$) were significant predictors.

Model 2 was built using backward stepwise logistic regression with both an entry and removal p value of .05. The summary scores on motor patterns ($p < .001$) and age ($p < .01$), the only significant predictors of verbal reports of pain, were included in Model 2. This model showed a slight improvement in sensitivity (64.2%) and specificity (81.3%) from Model 1.

The second research question helped us determine the best model for predicting verbal reports of pain. To identify the best model, we included in the regression individual scores on each of the five motor patterns (guarding, active rubbing, rigidity, unloading the joint, and joint flexion) instead of a summary score to search for the best model, using backward stepwise with both an entry and removal p value of .05. In Model 3, sensitivity (63.0%) and specificity (80.4%) remained about the same as in Model 2. Only guarding ($p < .001$) and joint flexion ($p < .01$), in addition to age ($p < .01$), were significant predictors. The final model explained 23.3% of the variance in verbal pain reports. Guarding and joint flexion explained 18.5% of the variance.

When Model 3 was applied to participants with knee OA alone, hip OA alone, or both knee and hip OA, age, guarding and joint flexion were significant predictors. The parameter

estimates from the models with subsamples (e.g., those with knee OA only) did not differ substantially from the final model that included the whole sample.

Given the high prevalence of pain in the elderly, the negative consequences of pain, and available treatment options, we wanted an assessment tool that captured a large proportion of elders with pain. Thus, good sensitivity was more important than good specificity. In addition, we wanted to keep the number of elders who had pain but were wrongly predicted as having no pain (false negatives) relatively low. To find the best tradeoff between sensitivity and specificity, the ROC curve with a fair to good *C* statistic of .78 (with standard deviation of 0.04) was calculated with cutoffs of 50%, 44%, 40% and 36% (Figure 1). To improve sensitivity, the cutoff predictive probability needed to be less than 50%. We decided to set 70.4% as the minimum for both sensitivity and specificity. Thus, 40–44% seemed a reasonable cutoff for predictive probability because sensitivity was 70.4% at the 44% cutoff. There was only a slow climb in sensitivity after the 40% cutoff. Increases in sensitivity were quite modest until reaching a 36% cutoff when sensitivity increased to 75.3%, but specificity decreased to 60.7%, which was unacceptable. With a 40 % cutoff (see Figure 1), the percentage of elders identified as having pain who actually had pain decreased about 5.6% (positive predictive value) from the 50% cutoff, and elders identified without pain who indeed had no pain improved about 2.7% (negative predictive value). In addition, with a cutoff of 40% for the predicted probability of pain, fewer pain behaviors needed to be identified than with a cutoff of 50%.

The probability of having pain for each individual elder can be calculated using the regression coefficients and constant shown in Table 2. A prediction equation was obtained from Model 3:

$$\text{Probability (reporting pain)} = \frac{1}{1 + e^{-[4.145 + (-.078) * \text{Age} + (.356) * \text{number of guarding} + (.557) * \text{numbers of joint flexion}]}}$$

According to this equation, the final model, which uses a 40% cutoff, can be applied to elders regardless of age and number of behaviors needed for each specific age group can be calculated. Fewer behaviors are required to correctly classify elders aged 60 as having pain, however. As age increases, the required number of behaviors either alone or in combination increases, and the combinations becomes more diverse. For example, an elder 60 years old needs 1 guarding or 1 joint flexion behavior to be identified as having pain. An elder at 80 needs 5 guarding behaviors, 4 joint flexion behaviors, or a combination of at least 4 behaviors to be identified as having pain.

Discussion

Only guarding and joint flexion were significant predictors of verbal reports of pain. Investigators who have studied movement-exacerbated pain in elders with cognitive impairment also found that guarding was a more sensitive behavioral indicator than bracing, rubbing, grimacing, or sighing (Hadjistavropoulos, LaChapelle, MacLeod, Snider, & Craig, 2000). Cognitive impairment is associated with Parkinsonian signs. These signs include guarding like behaviors and grow worse as the neurodegenerative process progresses. Thus, cognitively impaired elders might demonstrate more guarding than cognitively intact elders, and guarding behavior has been demonstrated to reflect cognitive function (Shega et al., 2008). By comparison, the vast majority of the elders in our sample were not affected by dementia. Further validation of our behavioral observation method is needed using a sample with the whole spectrum of MMSE scores.

An unexpected finding is that gait pattern was not associated with pain because relief of OA knee pain has been reported to enhance gait function (Shrader, Draganich, Pottenger, & Piotrowski, 2004). Hurwitz, Ryals, Case, Block, and Andriacchi (2002), however, found that knee adduction moment, a measurement of the load placed on the medial and lateral tibiofemoral compartments during walking, is related to physical function, but not pain in patients with OA. In the future, researchers may need to consider the influence of physical function on both pain and gait pattern. Also, our observational gait measure may not have been sensitive enough to detect differences between elders with pain and without pain. It would be advisable to include an objective measure of gait in future studies.

In addition to motor patterns, age was a significant predictor of verbal reports of OA knee or hip pain. This finding is similar to reports from other studies in which older participants were less likely to report pain (Gibson & Helme, 2001). It is possible, however, that the design of our study led to selection bias. That is, young elders who have OA pain may be less likely to survive to older ages, and the oldest old who are available to participate in studies may be very healthy and have less pain. Longitudinal studies are needed to verify this assumption. Researchers also have found that elders under-report pain, in part because they do not want to be labeled as complainers (Miaskowski, 2000). In addition, they may want to avoid bad consequences of reporting their pain, such as being admitted to a hospital or institutionalized (Pitkala, Strandberg, & Tilvis, 2002). Further, because OA is a chronic health condition and elders deal with OA pain on a daily basis, they may adapt to the pain, both mentally and physically, and therefore may not consider pain an experience that requires attention. Elders also have decreased sensitivity to low levels of noxious stimuli (Gibson & Helme, 2001). Although OA pain is persistent, we found that OA pain is not a high-intensity noxious stimulus in this study: the average VDS score in the pain group was only 1.5, indicating slight to mild pain. Thus, our oldest old participants in their 80s or 90s might not report pain because they are less sensitive to it.

The final model from this study, derived using only non-verbal cues, had a *C* statistic of .78 (with a standard deviation of 0.04). Although we excluded elders with other severe painful conditions of the lower extremities that required extensive analgesic control, non-severe pain may also affect elders' verbal reports and their behaviors. Further, because higher scores on guarding and/or joint flexion are required to identify pain in older people, the addition of variables associated with older age that might affect pain reports and/or fine motor patterns, such as walking speed or an objective measure of physical function, might strengthen the predictive ability of the model.

In the final model, the results for the subsample with knee OA differed from those for the sample as a whole. Age and joint flexion were only marginally significant in predicting pain among participants with knee OA alone. A future validation study may be needed to separate elders with OA knee pain, hip pain, and both knee and hip pain.

Given the high prevalence of OA hip and knee pain in elders who are unable or unwilling to verbally express pain, an assessment tool that accurately identifies their pain is needed. Except for Keefe's method (Keefe et al., 2001), current clinical pain observation tools do not capture the OA pain induced by daily activities such as standing and walking. Our study is a first step toward developing a clinical pain observation tool that makes it possible to calculate elders' probability of having pain. At this stage, this assessment model is intended for use in research, but future refinement may make it useful in clinical assessments. Identifying OA pain in elders with advanced age will require more pain cues, such as guarding and joint flexion behaviors, and diverse combinations of these nonverbal cues. This will pose challenges for assessment. To increase predictive ability, future researchers should include other variables, such as objective measures of physical function. In the

meantime, our final model can serve as a building block for the development of a tool to identify elders' pain when they cannot verbally report it.

Acknowledgments

This study was supported by a grant provided by the National Institute of Nursing Research (R15NR008405). It was also partially supported by the John A. Hartford Foundation, under the Building Academic Geriatric Nursing Capacity Scholar Program, the National Institute on Aging funded Alzheimer's Disease Center (P30 AG019606) and the National Institute of Arthritis and Musculoskeletal and Skin Disease grants (R01 AR054626 and P01 AR50245). The authors also thank Elizabeth Tornquist for editorial assistance. A version of the paper was presented as a poster at the American Pain Society annual conference in 2010. An abstract was published in the *Journal of Pain*, 11(4 Suppl), p. S1

References

- Allen KD, Oddone EZ, Coffman CJ, Keefe FJ, Lindquist JH, Bosworth HB. Racial differences in osteoarthritis pain and function: Potential explanatory factors. *Osteoarthritis and Cartilage*. 2010; 18:160–167.10.1016/j.joca.2009.09.010 [PubMed: 19825498]
- Astephen JL, Deluzio KJ, Caldwell GE, Dunbar MJ, Hubley-Kozey CL. Gait and neuromuscular pattern changes are associated with differences in knee osteoarthritis severity levels. *Journal of Biomechanics*. 2008; 41:868–876.10.1016/j.jbiomech.2007.10.016 [PubMed: 18078943]
- Bejek Z, Paroczai R, Illyes A, Kiss RM. The influence of walking speed on gait parameters in healthy people and in patients with osteoarthritis. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2006; 14:612–622.10.1007/s00167-005-0005-6
- Cornali C, Franzoni S, Gatti S, Trabucchi M. Diagnosis of chronic pain caused by osteoarthritis and prescription of analgesics in patients with cognitive impairment. *Journal of the American Medical Directors Association*. 2006; 7(1):1–5.10.1016/j.jamda.2005.06.010 [PubMed: 16413427]
- Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*. 1975; 12:189–198.10.1016/0022-3956(75)90026-6 [PubMed: 1202204]
- Fordyce, WE. Behavioral methods for chronic pain and illness. St. Louis, MO: C.V Mosby; 1976.
- Gibson SJ, Helme RD. Age-related differences in pain perception and report. *Clinics in Geriatric Medicine*. 2001; 17:433–456.10.1016/S0749-0690(05)70079-3 [PubMed: 11459714]
- Gönen, M. Analyzing receiver operating characteristic curves with SAS. Cary, NC: SAS Institute Inc; 2007.
- Gray WK, Hildreth A, Bilclough JA, Wood BH, Baker K, Walker RW. Physical assessment as a predictor of mortality in people with parkinson's disease: A study over 7 years. *Movement Disorders*. 2009; 24:1934–1940.10.1002/mds.22610 [PubMed: 19672988]
- Hadjistavropoulos, T.; Craig, KD. Social influences and the communication of pain. In: Hadjistavropoulos, T.; Craig, KD., editors. *Pain: Psychological perspectives*. New York, NY: Erlbaum; 2004. p. 87-112.
- Hadjistavropoulos T, LaChapelle DL, MacLeod FK, Snider B, Craig KD. Measuring movement-exacerbated pain in cognitively impaired frail elders. *Clinical Journal of Pain*. 2000; 16(1):54–63.10.1097/00002508-200003000-00009 [PubMed: 10741819]
- Herr KA, Mobily PR. Comparison of selected pain assessment tools for use with the elderly. *Applied Nursing Research*. 1993; 6:39–46.10.1016/S0897-1897(05)80041-2 [PubMed: 8439177]
- Herr KA, Spratt K, Mobily P, Richardson G. Pain intensity assessment in older adults: Use of experimental pain to compare psychometric properties and usability of selected scales with younger adults. *Clinical Journal of Pain*. 2004; 20:207–219.10.1097/00002508-200407000-00002 [PubMed: 15218405]
- Horgas AL. Assessing pain in persons with dementia. *MEDSURG Nursing*. 2007; 16:207–208. [PubMed: 17849932]
- Hurwitz DE, Ryals AB, Case JP, Block JA, Andriacchi TP. The knee adduction moment during gait in subjects with knee osteoarthritis is more closely correlated with static alignment than radiographic

- disease severity, toe out angle and pain. *Journal of Orthopaedic Research*. 2002; 20:101–107.10.1016/S0736-0266(01)00081-X [PubMed: 11853076]
- Keefe FJ, Caldwell DS, Queen K, Gil KM, Martinez S, Crisson JE, Nunley J. Osteoarthritic knee pain: A behavioral analysis. *Pain*. 1987; 28:309–321.10.1016/0304-3959(87)90066-2 [PubMed: 2952935]
- Keefe, FJ.; Williams, DA.; Smith, SJ. Assessment of pain behaviors. In: Turk, DC.; Melzack, R., editors. *Handbook of pain assessment*. 2. New York, NY: Guilford Press; 2001. p. 170-187.
- Kegelmeyer DA, Kloos AD, Thomas KM, Kostyk SK. Reliability and validity of the Tinetti mobility test for individuals with parkinson disease. *Physical Therapy*. 2007; 87:1369–1378.10.2522/ptj.20070007 [PubMed: 17684089]
- Lopez MN, Charter RA, Mostafavi B, Nibut LP, Smith WE. Psychometric properties of the folstein mini-mental state examination. *Assessment*. 2005; 12:137–144.10.1177/1073191105275412 [PubMed: 15914716]
- McCrory JL, White SC, Lifeso RM. Vertical ground reaction forces: Objective measures of gait following hip arthroplasty. *Gait & Posture*. 2001; 14:104–109.10.1016/S0966-6362(01)00140-0 [PubMed: 11544061]
- Mejjad O, Favre S, Dujardin F, Thomine J, Le Loet X, Weber J. Efficacy of etodolac on gait in hip osteoarthritis as assessed by bessou's locometer: A randomized, crossover, double-blind study versus placebo. *Osteoarthritis and Cartilage*. 2000; 8:230–235.10.1053/joca.1999.0294 [PubMed: 10806051]
- Miaskowski C. The impact of age on a patient's perception of pain and ways it can be managed. *Pain Management Nursing*. 2000; 1(3 Suppl 1):2–7.10.1053/jpmn.2000.9760 [PubMed: 11710146]
- National Institutes of Health. Fact sheet: Osteoarthritis. 2007. Retrieved from <http://www.nih.gov/about/researchresultsforthepublic/Osteoarthritis.pdf>
- O'Connor MI. Osteoarthritis of the hip and knee: Sex and gender differences. *The Orthopedic Clinics of North America*. 2006; 37:559–568.10.1016/j.ocl.2006.09.004 [PubMed: 17141013]
- Paradowski PT, Bergman S, Sundén-Lundius A, Lohmander LS, Roos EM. Knee complaints vary with age and gender in the adult population. Population-based reference data for the knee injury and osteoarthritis outcome score (KOOS). *BMC Musculoskeletal Disorders*. 2006; 7:38. doi:10.1186/1471-2474-7-38. [PubMed: 16670005]
- Perneckzy R, Wagenpfeil S, Komossa K, Grimmer T, Diehl J, Kurz A. Mapping scores onto stages: Mini-mental state examination and clinical dementia rating. *The American Journal of Geriatric Psychiatry*. 2006; 14:139–144.10.1097/01.JGP.0000192478.82189.a8 [PubMed: 16473978]
- Pitkala KH, Strandberg TE, Tilvis RS. Management of nonmalignant pain in home-dwelling older people: A population-based survey. *Journal of the American Geriatrics Society*. 2002; 50:1861–1865.10.1046/j.1532-5415.2002.50517.x [PubMed: 12410908]
- Reynolds KS, Hanson LC, Devellis RF, Henderson M, Steinhäuser KE. Disparities in pain management between cognitively intact and cognitively impaired nursing home residents. *Journal of Pain and Symptom Management*. 2008; 35:388–396.10.1016/j.jpainsymman.2008.01.001 [PubMed: 18280101]
- Shega JW, Rudy T, Keefe FJ, Perri LC, Mengin OT, Weiner DK. Validity of pain behaviors in persons with mild to moderate cognitive impairment. *Journal of the American Geriatrics Society*. 2008; 56:1631–1637.10.1111/j.1532-5415.2008.01831.x [PubMed: 18662203]
- Shrader MW, Draganich LF, Pottenger LA, Piotrowski GA. Effects of knee pain relief in osteoarthritis on gait and stair-stepping. *Clinical Orthopaedics and Related Research*. 2004; 421:188–193.10.1097/01.blo.0000119248.70353.a5 [PubMed: 15123946]
- Sterke CS, Huisman SL, van Beeck EF, Looman CW, van der Cammen TJ. Is the Tinetti Performance Oriented Mobility Assessment (POMA) a feasible and valid predictor of short-term fall risk in nursing home residents with dementia? *International Psychogeriatrics*. 2010; 22:254–263.10.1017/S1041610209991347 [PubMed: 19951457]
- Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *Journal of the American Geriatrics Society*. 1986; 34:119–126. [PubMed: 3944402]

Tukker A, Visscher TL, Picavet HS. Overweight and health problems of the lower extremities: Osteoarthritis, pain and disability. *Public Health Nutrition*. 2009; 12:359–368.10.1017/S1368980008002103 [PubMed: 18426630]

Figure 1.
Receiver operating characteristic curve for finding the best sensitivity and specificity for elders who cannot verbally express pain

Table 1

Participants' Characteristics

Characteristics	Total sample	Osteoarthritis status		<i>p</i> ^a
	(<i>n</i> =192)	Yes (<i>n</i> =104)	No (<i>n</i> =88)	
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	
Age	73.5 (7.7)	72.4 (7.2)	74.7 (8.1)	.035
Sex (% Female)	77.1 %	86.5 %	65.9 %	.001
Race (% White)	84.9 %	84.6 %	85.2 %	1.00
Body mass index	27.6 (5.3)	28.5 (5.6)	26.6 (4.8)	.014
Mini Mental State Exam	28.7 (1.8)	28.6 (1.9)	28.7 (1.5)	.824
Gait pattern	11.2 (1.1)	11.2 (1.2)	11.3 (1.0)	.453
Motor pattern	3.9 (3.7)	5.4 (3.6)	2.2 (2.9)	<.001
Pain	0.85 (1.2)	1.5 (1.3)	0.1 (0.4)	<.001

Note.

^aBased on the results of either a *t*-test or chi-square test.

Table 2

Results from the Logistic Regression for Predicting Verbal Report of Pain

Variables	Model 1		Model 2		Model 3	
	B ^a	SE	B ^a	SE	B ^a	SE
Age	-.06*	.03	-.07**	.02	-.08**	.02
Sex	.68	.45				
Race	.65	.55				
Body mass index	.06	.04				
Gait pattern	.14	.17				
Motor pattern	.29***	.06	.31***	.06		
Guarding					.36***	.07
Joint flexion					.56**	.21
Constant	-1.44	3.25	3.85*	1.69	4.15*	1.72
Sensitivity <i>b</i>	60.5%		64.2%		63.0%	
Specificity <i>b</i>	80.4%		81.3%		80.4%	

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

^a Estimated value of unstandardized regression coefficient.

^b Based on 50% predicted probability.