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Testing the Integration of *ICF* and Behavioral Models of Disability in Orthopedic Patients: Replication and Extension

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Objective: Disability from chronic illness is a major problem for society, yet the study of its determinants lacks an overall theoretical paradigm. Johnston (1996) has proposed conceptualizing disability as behavior and integrating biomedical and behavioral predictors. Dixon, Johnston, Rowley, and Pollard (2008) tested a model including constructs from the *International Classification of Functioning, Disability and Health* (ICF) and the theory of planned behavior (TPB) using structural equation modeling; it fitted better and explained more variance than the ICF or TPB alone. We replicated their study with a new sample from the same population (orthopedic patients awaiting joint replacement) and also tested the model after the patients had surgery. ***Methods:*** Two weeks before surgery, 342 orthopedic patients who had joint pain (most with arthritis) completed a questionnaire, with 228 completing it again 1 year after surgery. The authors tested Dixon et al.'s best-fit models cross-sectionally (before and after surgery) and assessed the goodness of fit of these imposed models to our data using structural equation modeling. ***Results:*** Findings strongly supported those of Dixon et al. Before surgery, results were very similar to Dixon et al. with all models accounting for significant variance and fitting well, but the integrated model fitted better and accounted for more variance. One year after surgery, Dixon et al.'s models showed even stronger fit to the data. ***Conclusions:*** Although behavioral and biomedical (ICF) models were supported, the integrated model provided a better explanation of disability in this population than either of these models alone and suggests biopsychosocial interventions to reduce disability.

Keywords: disability, ICF, theory of planned behavior, osteoarthritis, behavior

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Impact and Implications

- This work replicates and expands on previous research (published in *Rehabilitation Psychology*), confirming that an integrated biomedical and behavioral model explains walking limitation in orthopedic patients better than either model alone. Previous supportive results are unlikely to have been due to chance.
- In considering factors that might predict patients' activity limitations, practitioners might consider patients' cognitions such as perceived control as well as their pain.
- Psychological factors (especially perceived control) should be considered to design biopsychosocial interventions and care plans for orthopedic patients to minimize activity limitations after joint replacement.

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Introduction

For people who are chronically ill or recovering, mobility limitations can be a major form of disability. Difficulty walking can cause difficulty with almost every aspect of life, from going to the mailbox and shopping for groceries, to maintaining a social life and accessing services such as health care.

Much scientific research on the determinants of disability originates in the medical literature, often emphasizing physiological disorder as the main determinant. This "biomedical approach" is exemplified in the World Health Organization (WHO) model of disability, the *International Classification of Impairments, Disabilities and Handicaps*, or *ICIDH* (WHO, 1980). *Impairment* (loss or abnormality of psychological or physiological structure or function) was proposed to cause *disability* (restriction of ability to perform an activity in the manner or range considered normal for a human being), which in turn caused *handicap*, depending on the

context (inability to fulfill a social role considered normal in that environment, considering age, sex, social circumstances, etc.). For example, in a person with osteoarthritis, disability would be expected to be directly proportional to pain and underlying joint damage (impairment). However, the sufficiency of this model is challenged by research and clinical experience.

In clinical practice, a "disability paradox" is often noticeable, as two individuals may have the same severity of abnormality of body structure or function (impairment) but different levels of disability. These clinical observations suggest that underlying pathology is not the sole determinant of disability, and in a test of the ICIDH in patients recovering from stroke, weak and inconsistent correlations were found between impairment and disability (Johnston & Pollard, 2001). Furthermore, changes in impairment are not necessarily related to changes in disability. Flor, Fydrich, and Turk (1992) reviewed treatment outcomes at multidisciplinary pain centers and found that reduced pain was unrelated to changes in activity level or return to work. Interventions based on the biomedical approach typically target underlying pathology with drugs or surgery; however, for many chronic conditions no such treatment is currently available or only partial relief is possible, leaving no theoretical avenue to minimize disability.

Psychologists have also researched behavioral determinants of disability. Among these, control cognitions (beliefs about to what extent one's actions can control the environment or personal consequences) have been consistently supported. For example, following stroke, perceived control over recovery predicted change in disability when controlling for impairment and other clinical variables (Johnston, Morrison, MacWalter, & Partridge, 1999; Partridge & Johnston, 1989) and predicted recovery after 3 years (Johnston, Pollard, Morrison, & MacWalter, 2004). Self-efficacy and perceived behavioral control (PBC) predicted disability and recovery from stroke 6 months after discharge (Bonetti & Johnston, 2008), and in orthopedic patients self-efficacy to perform activities of daily living predicted disability after joint replacement (Orbell, Johnston, Rowley, Davey, & Espley, 2001).

There is also experimental support for control cognitions as causal: Fisher and Johnston (1996a) increased or decreased disability on a lifting task in patients with chronic pain by manipulating perceived control at clinical interview. Emotions such as anxiety are also relevant. Manipulating anxiety has been shown to alter level of disability in chronic pain (Fisher & Johnston, 1996b), and in vivo exposure as suggested by the fear-avoidance model (Lethem, Slade, Troup, & Bentley, 1983; Vlaeyen, Kole-Snijders, Rotteveel, Ruesink, & Heuts, 1995) has been found to reduce disability without necessarily reducing pain or underlying pathology (for a review see Leeuw et al., 2007). However, optimal interventions for disability are likely to be complex, targeting biomedical, psychological, and contextual variables. Development of such interventions has been slowed by the lack of an interdisciplinary theoretical framework (Dixon et al., 2008), but several developments have brought this goal closer to realization.

Johnston's Integrated Model: Disability as Behavior

Johnston (1996) argued that disability could be seen as behavior (or absence of behavior), such that individuals perform or do not perform tasks or activities. Fordyce had experienced success with increasing activity levels in patients with chronic pain (among other pain behaviors) by treating inactivity as behavior and using positive reinforcement for activity and elimination of environmental reinforcement for inactivity (e.g., Fordyce, Fowler, & Delateur, 1968). Furthermore, across diagnoses, patterns of disability were found to be similar, with an element of selectivity in which activities were retained. The most critical tasks (rather than easiest) tended to be those spared (e.g., feeding, toileting), irrespective of how much energy they required—as if directing limited resources only to the most valued tasks (Williams, Johnston, Willis, & Bennett, 1976). Conceptualizing disability as behavior makes disability easier to define and measure, connects its study to extensive scientific knowledge of the determinants of behavior, and suggests theory-based interventions. Johnston (1996) proposed to integrate constructs from the theory of planned behavior (TPB; Ajzen, 1985, 1991) or social–cognitive theory (SCT; Bandura, 1986) as mediators between the constructs of impairment and disability from ICIDH (while maintaining the direct link); TPB and SCT possessed good evidence bases and well-developed measures. This article focuses on constructs from the TPB.

The TPB developed from research into the effect of attitudes on behavior. It proposes that behavior is determined by intention to perform it and perceived behavioral control (PBC) over it (PBC is related to and overlaps with self-efficacy; Ajzen, 1991). Intention is determined by attitudes toward the behavior, PBC, and subjective norm (essentially the attitudes of others toward the behavior and how much store one sets by others' attitudes). The TPB's ability to predict many forms of health behavior has been supported by several reviews and meta-analyses (e.g., Armitage & Conner, 2000, 2001; Godin & Kok, 1996). From Johnston's (1996) perspective, someone who does not perform a behavior may be unable to or believe that performing the behavior would have negative consequences (attitudes), that they cannot do so successfully (PBC), or both.

The International Classification of Functioning, Disability, and Health (ICF)

Following the development of Johnston's integrated model, a second conceptual development was the publication by the WHO (2001) of the *International Classification of Functioning, Disability and Health* (ICF). Designed to address criticisms of and replace the ICIDH (Peterson, 2005), the ICF is a taxonomy that describes health in terms of functioning and a conceptual framework for understanding functioning. It includes the relationship between impairment (abnormality of body structure and function) and activity limitation, which replaced the ICIDH construct of disability. The third health component, participation restriction (involvement in life situations), replaced but differs from handicap. The framework and potential relationships are shown in Figure 1. Rather than a formal model like the ICIDH, the ICF is more of a conceptual framework including reciprocal relationships, for researchers to use as a scaffold on which to build causal models. The framework is informed by a biopsychosocial model of disability and permits nonbiomedical variables to affect all constructs, as the domains of *environmental factors* and *personal factors* connect throughout, although the latter have not been specified in detail and further development is needed (Geyh et al., 2011).

Although criticized as vague and underdeveloped (Imrie, 2004), the ICF represents an advance on ICIDH (Peterson, 2005) and

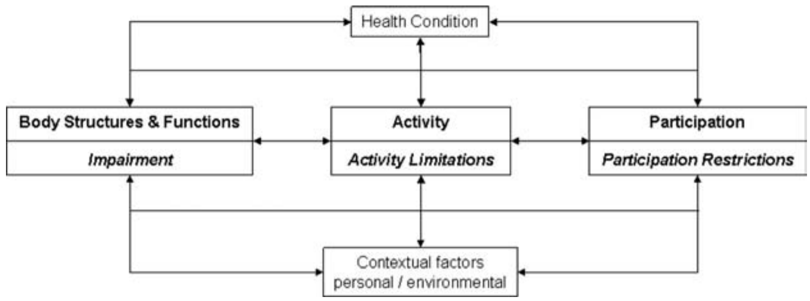

Figure 1. Schematic representation of the *International Classification of Functioning, Disability and Health* (ICF; World Health Organization, 2001), with disability versions of the central constructs in italics. From ICF (p. 18) by World Health Organization, 2001, Geneva, Switzerland.

invites investigation of how nonphysiological variables may contribute to activity limitation and participation restrictions, in the form of personal and environmental factors. There is potential for research to evaluate the validity of theoretical models based on this framework (Bruyère, Van Looy, & Peterson, 2005), which could integrate biomedical and behavioral approaches to form the basis of a cumulative science of disability.

Testing an Integrated Model

A few studies have tested Johnston's (1996) model explicitly, but replacing the ICIDH components with those from ICF. The integrated model has usually explained more variance in activity limitation (e.g., walking) than impairment alone. Schröder et al. (2007) tested intention, PBC and emotional distress as mediators between impairment and activity limitation in walking in patients with a neurological disorder. PBC predicted (and mediated) activity limitation, but intention was not predictive. Dixon et al. (2008) used structural equation modeling (SEM) to test three models: an integrated model based on Johnston's (1996) propositions, a simple impairment–activity limitation model, and a TPB model. Their integrated model is shown in Figure 2.

Participants were orthopedic patients scheduled for joint replacement surgery; most had osteoarthritis and all experienced joint pain. Dixon et al. (2008) operationalized impairment as pain and activity limitation as walking, as Pollard, Johnston, and Dieppe (2006) had found measures of pain to have discriminant content validity as a measure of impairment, and because walking is an important form of activity limitation in this population and appears in the ICF core set for osteoarthritis. Participants completed questionnaires measuring pain (impairment), TPB constructs related to walking, self-reported ability to walk a certain distance (activity limitation), as well as other items. Using SEM, Dixon et al. examined whether the integrated model was a better fit to the data and explained more variance than ICF or TPB models alone. This was found to be the case. However, as Schröder et al. (2007) found, only PBC mediated significantly between impairment and activity limitation, with intention not predictive.

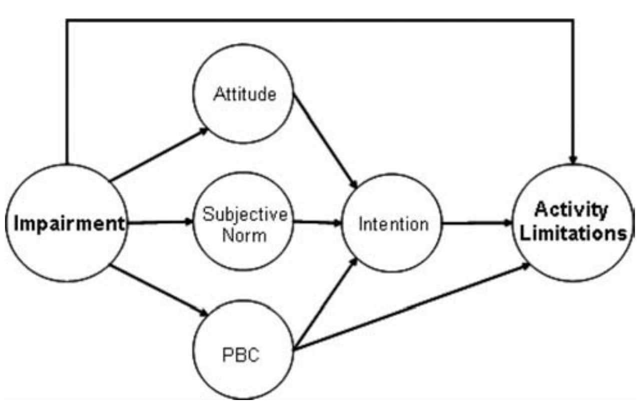

Figure 2. Integrated biomedical and behavioral model of activity limitations: the theory of planned behavior (TPB) integrated into *International Classification of Functioning, Disability and Health*, as tested by Dixon et al. (2008). PBC = perceived behavioral control.

Although these results support Johnston's (1996) model, SEM is a correlational technique that can capitalize on chance findings and requires replication. Furthermore, relatively few studies have tested the integrated model explicitly. It seemed desirable to replicate Dixon et al.'s (2008) study with a new sample from the same population. Accordingly, in the study presented here, we used SEM to test the same three models of activity limitation as Dixon et al. We did not test the full TPB model but investigated only the constructs of intention and PBC as the theory proposes these are the direct predictors of behavior.

Rather than investigating the best-fitting statistical models, we imposed the measurement models and structural models found to fit the data in Dixon et al.'s study and tested the fit of these models to the new data. If Johnston's propositions are supported, the integrated model should show better goodness of fit and explain greater variance in activity limitation than the others. Then, we extended Dixon et al.'s study by testing the models in the same participants 1 year after joint replacement surgery, that is, after a change in body structure and function.

Method

Design

Participants completed a questionnaire at two time points: approximately 2 weeks before hospital admission for joint replacement surgery and 1 year after the operation; this time period was selected to allow maximum recovery from surgery (Ghomrawi, Kane, Eberly, Bershadsky, & Saleh, 2009; Nilsdotter & Lohmander, 2002).

Theoretical models were tested cross-sectionally at both time points using SEM, imposing Dixon et al.'s best-fit measurement and structural models. Participants were a new sample recruited from the same population using the same methods as in Dixon et al.'s study but at a later date; they completed the same measures. These methods are described fully in Dixon et al. (2008).

Participants

All participants were orthopedic patients scheduled for joint replacement surgery of the knee or hip in the next 2 weeks.

Time 1 (Presurgery). Participating were 342 patients (51% women) aged 37 to 95 years (*M* = 70). Most were married (65%) or widowed (23%). All except one reported their ethnicity as White, with the remaining participant Asian. Most had a high school education (71%) or a further education diploma (15%); some held a college degree (8%). Most did not work (85%), primarily being retired (75%). Diagnoses included osteoarthritis (93%), rheumatoid arthritis (2.5%) or another form of arthritis, or avascular necrosis (1%). Self-reported pain over the previous month on a 10-cm visual analogue scale (VAS) was a mean of 7.10 (*SD* = 1.99, range = 0 to 10). Joints to be replaced were left knee (25%), right knee (22%), left hip (25%), and right hip (27%).

Time 2 (Postsurgery). One year after surgery, 228 patients (67%) returned the follow-up questionnaire 12 to 14 months after their operation date; the others did not reply (*n* = 99) or returned the questionnaire earlier or later or left the questionnaire undated (*n* = 15). Ages were 46 to 90 years (*M* = 70). Other demographics were the same as Time 1 (T1). Diagnoses were similar to T1, primarily osteoarthritis (93%), rheumatoid arthritis (3%), avascular necrosis (1%), and the remainder other forms of arthritis. Mean pain during the previous 4 weeks on the 10-cm VAS was 1.3 (*SD* = 1.93, range = 0 to 10).

Measures

Full details of item development and validation of measures is reported in Dixon et al. (2008). Measures were identical at both timepoints, except that in the presurgery (T1) questionnaire, TPB measures related to walking 100 yards and in the postsurgery (T2) questionnaire to walking half a mile; this was based on Dixon et al.'s pilot work, which indicated that after joint replacement most participants would find walking 100 yards relatively easy, leading to a ceiling effect. Measures reproduced here are those used by Dixon et al. in their final measurement models. As in Dixon et al., the ICF model was limited to the constructs of impairment and activity limitation and in the TPB model only the proximal predictors of intention and PBC were included. Items were reverse scored where necessary so that greater scores indicated greater levels of the construct, and all items are referred to by the same labels as in Dixon et al.

Impairment (ICF). This was operationalized as arthritis–joint pain and measured by four items (Items I1–I4) identified from health status questionnaires by Pollard et al. (2006) as pure measures of impairment, uncontaminated by activity limitation; items were from Dawson, Fitzpatrick, Carr and Murray (1996), Lequesne (1991), and Meenan, Gertman and Mason (1980). Items were as follows: "How would you describe the pain you usually have in your joint?" (I1); "How often have you had severe pain from your arthritis?" (I2); "Does remaining standing for 30 minutes increase your pain?" (I3); and "Have you had any sudden, severe pain–shooting, stabbing or spasms from the affected joint?" (I4). Items were rated on 5-point Likert scales scored from 1 to 5. Item 1 anchors ranged from 1 (*none*) to 5 (*extreme*); and Items 2, 3, and 4 ranged from 1 (*never*) to 5 (*all of the time*).

Activity Limitation (ICF). This was operationalized as walking limitation and measured by three items (Items W1–W3), modified from the *Rand 36-Item Short Form Health Survey,* by Rand Corporation (2008, http://www.rand.org/health/surveys_tools/mos/mos_core_36item_terms.html, Copyright 2008 by Rand Corporation; the *Rand survey* was developed at Rand as part of the Medical Outcomes Study). Participants were asked, "Does your health now limit you in these activities? If so, how much?" followed by the following items: "Walking 100 yards?" (W1); "Walking half a mile?" (W2); and "What degree of difficulty do you have walking long distances on the flat (more than half a mile)?" (W3). W1 and W2 were scored on a 3-point Likert scale with anchors ranging from 1 (*yes, limited a lot*) to 3 (*no, not limited at all*), whereas W3 was scored on a 5-point Likert scale with anchors ranging from 1 (*none*) to 5 (*extreme*). W1 and W2 were from the SF-36 (Rand Corporation, 2008): Using discriminant content validation, Pollard et al. (2006) had found these items to be pure measures of activity limitation, uncontaminated by impairment. Item W3 was created for Dixon et al.'s study.

Intention (TPB). This was measured by two items (Items INT1 & INT3): "I intend to do a walk of 100 yards/half a mile" (INT1); and "It is likely that I will do a walk of 100 yards/half a mile" (INT3). Both were scored on a 5-point Likert scale with anchors ranging from 1 (*strongly agree*) to 5 (*strongly disagree*).

Perceived behavioral control (TPB). Four items (Items PBC3–PBC6) measured PBC: "I have complete control over doing a walk of 100 yards/half a mile" (PBC3); "There are likely to be plenty of opportunities for me do a walk of 100 yards/half a mile" (PBC4); "I have complete control over doing a walk of 100 yards/half a mile" (PBC5); and "I feel in complete control over whether I do a walk of 100 yards/half a mile" (PBC6). All were scored on a 5-point Likert scale with anchors ranging from 1 (*strongly agree*) to 5 (*strongly disagree*).

Procedure

Full details of recruitment and data collection procedure at Time 1 are published in Dixon et al. (2008). Briefly, consecutive patients scheduled for elective joint replacement surgery at a hospital in Dundee, Scotland were invited to participate at presurgery screening in the hospital, approximately 2 weeks before surgery. Those who accepted received consent materials, a questionnaire and prepaid envelope, and were asked to complete the questionnaire at home (but before surgery) and mail it to the investigators. Median time between questionnaire completion and surgery was 15 days (*M* = 32 days; *SD* = 77 days). Some participants subsequently had their operation delayed and rescheduled; these were included in the analysis as their expectation of surgery when completing the questionnaire was the same as that of other participants.

At T2, approximately 1 year after surgery, another questionnaire was mailed to all participants who returned the T1 questionnaire. Participants were requested to fill it out and mail it back to the

research team using a prepaid envelope. The study was approved by the Medical Research Ethics Committee of NHS Tayside.

Analysis

Structural equation modeling was performed using EQS 6.1 (Bentler, 2004) to assess the degree of fit between hypothesized models and the data, estimate path coefficients, and calculate variance explained. All analyses used covariance matrices and maximum likelihood estimation. No variable had more than 5% missing values, and these were imputed in SPSS 17.0 using the expectation maximization (EM) method. Although Dixon et al. (2008) used mean imputation, this is no longer recommended, and EM is one of several currently regarded as appropriate (Tabachnick & Fidell, 2007). Data were then exported to EQS.

Rather than transforming nonnormal variables, robust fit indices were calculated using EQS, as recommended by Bentler (2005) and Ullman (1996); these render unnecessary any data transformations due to nonnormality (Bentler, 2005). All fit indices reported include a correction by the software for robustness.

Questionnaire items were used to create latent variables, which were used in the structural analyses. First, the final measurement models of Dixon et al. (2008) were applied to the data and the adequacy of these models established using confirmatory factor analysis (CFA). Factor variances were fixed at one to identify the model and allow all factor loadings to be calculated; all factors were allowed to covary. When testing the integrated model, because indicators of all latent factors had been tested previously, CFA was omitted.

Next, goodness of fit to the data was examined for each structural model. To scale each factor, the path coefficient between the factor and one indicator was fixed at one, allowing factor variances to be estimated. We evaluated the significance of mediation effects using tests of indirect effects in EQS (Sobel, 1982), which has more power than Baron and Kenny's (1986) approach. The standardized indirect effect coefficient reported represents the total strength of all indirect effects of one variable on another. In some cases only one such indirect effect may be possible.

We report the Satorra-Bentler chi-square statistic, which is robust to data nonnormality (Bentler & Djikstra, 1985). The value should be nonsignificant, but it is sensitive to large sample sizes so other fit indices are also reported. A model is generally accepted as being a good fit if multiple fit indices indicate this even if chi-square is significant. We also report the nonnormed fit index (NNFI; Tucker & Lewis, 1973), comparative fit index (CFI; Bentler, 1990), and root-mean-square error of approximation (RMSEA; Nevitt & Hancock, 2000). These are frequently used and were reported by Dixon et al. (2008); they display low random variation under conditions typically found in SEM (Fan, Thompson, & Wang, 1999). For the NNFI and CFI, a value of .90 or above represents adequate model fit, and over .95 indicates good fit (Kline, 2005). For the RMSEA, values between .10 and .08 represent adequate fit (MacCallum, Browne, & Sugawara, 1996), with values of .08 and under indicating good fit (Browne & Cudeck, 1993).

As a measure of parsimony, Akaike's information criterion (AIC; Akaike, 1987) was also calculated for each model. Values are not absolute but are relative to other models tested, and values closer to zero (irrespective of sign) indicate greater parsimony. Because the purpose of the study was replication, post hoc model modification statistics such as the Lagrange multiplier (LM) and Wald tests were not calculated. In all diagrams, latent factors are enclosed in ellipses. Because EQS 6.1 does not report exact *p* values, significance at the 5% level is indicated in text or by an asterisk.

Results

Sample Size and Statistical Power at T1 and T2

Sample-size requirements for SEM depend on the number of free parameters in the model (Kline, 2005; MacCallum et al., 1996; Schumacker & Lomax, 2004). A ratio of sample size to free parameters of 5:1 or 10:1 is frequently recommended as a rule of thumb (Bentler, 2005; Nunnally, 1978). At T1 the sample size of 342 was adequate at these ratios for all models. However, at T2 the sample size of 228 was not adequate at the 10:1 ratio for the integrated model; as a result power may be limited for this model at T2.

Analysis of Participant Drop Out

Independent-samples *t* tests and chi-square calculations indicated that those who did not return the T2 questionnaire did not differ significantly from those who did on presurgery pain, sex, age, educational level, or employment status. Ethnic origin did not change. Table 1 shows means and standard deviations and results of independent-samples *t* tests for study variables comparing those who dropped out from those who did not. There were no significant differences for intention or PBC, but the drop-out group had

Table 1
*Comparisons Between Variable Scores for Those Who Dropped Out (*N = 99*) and Did Not Drop Out (*N = 243*) at T2*

	Dropped out		Did not drop out					95% CI		
Variable	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Lower	Upper	*d*
Impairment	3.66	0.67	3.52	0.66	1.86	340	.06	−.01	.30	.20
Activity limitation	3.04	0.62	2.83	0.69	2.61	340	.01*	.05	.37	.28
Intention	3.63	1.04	3.65	1.07	−0.21	340	.84	−.28	.22	.02
PBC	3.24	0.77	3.36	0.59	−1.40	147[a]	.16	−.29	.04	.18

Note. CI = confidence interval. Scores range 1 to 5.
[a] Levene's test for equality of variances returned a significant value of *F* and therefore *df*s were reduced for a more conservative test.
* $p < .05$.

significantly greater activity limitation at T1, and the value of t for impairment approached significance ($p = .06$). However, these effect sizes were small.

Descriptive Statistics and Intercorrelations

Means, standard deviations, intercorrelations, and scale reliability (Cronbach's alpha) are presented for the composite observed variables at both time points in Table 2. All showed satisfactory reliability ($\alpha > .60$), with all alphas exceeding .70.

Changes Following Joint Replacement

Paired-samples t tests indicated a significant change between T1 and T2 for all variables in Table 2. At T2 there were large reductions in impairment, $t(227) = 27.43$, $p < .001$, 95% confidence interval (CI) [1.37, 1.58], $d = 1.82$; and in activity limitation, $t(227) = 21.43$, $p < .001$, 95% CI [0.97, 1.17], $d = 1.42$. There were small increases for intention and PBC, perhaps because items used to measure these constructs at T1 and T2 referred to walking different distances. For intention, $t(227) = -3.99$, $p < .001$, 95% CI [−0.44, −0.15], $d = 0.26$, a small effect; and for PBC, $t(227) = -4.38$, $p < .001$, 95% CI [−0.24, −0.09], $d = 0.29$, a small effect.

Pain reported (i.e., pain during the past 4 weeks) between T1 and T2 reduced on average by 5.7 points on the 10-cm VAS ($SD = 2.42$). A paired-samples t test indicated that mean 4-week pain was significantly lower at T2 compared with T1, $t(223) = 35.13$, $p < .001$, 95% CI [5.36, 5.99], $d = 2.34$, a large effect. However the spread of difference scores (range = −10.0–1.9) suggested that after surgery, although most participants experienced less pain (to a greater or lesser extent) and some became pain-free, 8 reported slightly worse pain.

Time 1 (Presurgery): ICF Model

Measurement model. All impairment items (Items I1– I4) and all activity limitation items (Items W1–W3) were hypothesized to load onto their respective factors. The model was an adequate fit, Satorra-Bentler $\chi^2(13) = 55.99$, $p < .001$, NNFI = .91, CFI = .94, RMSEA = .10. Standardized residuals were small and normally distributed. Parameter estimates of indicators, factor variance explained by each indicator and interfactor correlations for all measurement models tested can be found online as supplemental material to this article.

Structural model. Impairment was hypothesized to directly and positively predict activity limitation. Adequate support was found for the model from the fit indices, Satorra-Bentler $\chi^2(13) = 55.95$, $p < .001$, NNFI = .91, CFI = .94, RMSEA = .10, AIC = 29.95. Impairment significantly predicted activity limitation ($\beta = .59$), and the R^2 value indicated that 35% of the variance in activity limitation was accounted for.

Time 1 (Presurgery): TPB Model

Measurement model. For Intention, PBC and Activity Limitation, all items presented earlier acted as indicators of their respective latent variables. The model showed adequate fit, Satorra-Bentler $\chi^2(24) = 89.24$, $p < .001$, NNFI = .95, CFI = .96, RMSEA = .09. Standardized residuals were small and normally distributed.

Structural model. The structural model and fit indices are presented in Figure 3. The NNFI and CFI showed good model fit although the RMSEA indicated adequate fit, just short of the good-fit cutoff of .08. Intention and PBC accounted for 48% of the variance in activity limitation, and PBC accounted for 77% of the variance in intention. Intention did not significantly predict activity limitation ($\beta = -.13$), but greater PBC was strongly predictive of lower activity limitation ($\beta = -.57$). Greater PBC also significantly predicted greater intention ($\beta = .87$).

Time 1 (Presurgery): Integrated Model

The same observed variables indicated each latent factor as in the *ICF* and TPB models. Therefore, results for the measurement model are omitted. The integrated model is shown in Figure 4; model fit was adequate according to the NNFI and RMSEA and good according to the CFI. Values of R^2 indicated that the model accounted for 59% of the variance in Activity Limitation, with 77% of the variance in Intention and 20% of the variance in PBC accounted for by their predictors.

Impairment significantly predicted Activity Limitation ($\beta = .35$). PBC predicted reduced Activity Limitation ($\beta = -.43$) but Intention was not a significant predictor ($\beta = -.12$). Greater Impairment significantly predicted reduced PBC ($\beta = -.45$) but not Intention ($\beta = -.02$). Intention was strongly predicted by PBC ($\beta = .87$). PBC mediated between Impairment and Activity Limitation (standardized indirect effect coefficient = .24, $p < .05$), such that more severe Impairment predicted less PBC, which in turn predicted greater Activity Limitation.

Table 2
Scale Reliability (Cronbach's α), Descriptive Statistics, and Scale Intercorrelations (Pearson's R) at T1 and T2

Variable	α	*M*	*SD*	1	2	3	4
1. Impairment	.74/.78	3.56/2.04	0.67/0.80	—	.60	−.37	−.41
2. Activity limitation	.83/.86	2.89/1.77	0.68/0.78	.50	—	−.74	−.76
3. Intention	.88/.96	3.64/3.91	1.06/1.07	−.37	−.56	—	.87
4. PBC	.91/.93	3.35/3.51	0.60/0.57	−.39	−.61	.79	—

Note. First value in each cell (before the slash) refers to T1, while second refers to T2 (i.e. T1/T2). Correlations below the diagonal refer to T1, while those above the diagonal refer to T2. All scores are on a 1 to 5 scale. All correlations are significant at $p < .01$.

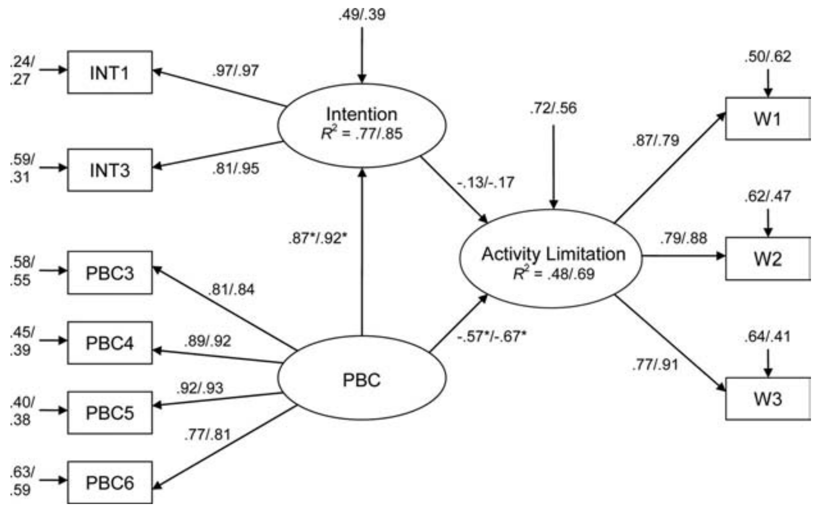

Figure 3. INT = intention; W = walking; PBC = perceived behavioral control. Standardized coefficients for theory of planned behavior (TPB) model at Time 1 (T1) and T2. First value presented relates to T1, while second relates to T2 (i.e. T1/T2). Fit indices at T1: Satorra-Bentler $\chi^2(24) = 89.25$, $p < .001$, nonnormed fit index (NNFI) = .95, comparative fit index (CFI) = .96, root-mean-square error of approximation (RMSEA) = .09, (Akaike's information criterion) AIC = 41.24. Fit indices at T2: Satorra-Bentler $\chi^2(24) = 42.59$, $p = .05$, NNFI = .98, CFI = .98, RMSEA = .06, AIC = −5.41. * $p < .05$.

Time 2 (Postsurgery): ICF Model

Measurement model. The measurement model was the same as at T1. Standardized residuals were small and normally distributed. The model was a good fit, Satorra-Bentler $\chi^2(13) = 29.81$, $p = .005$; NNFI = .96, CFI = .98, RMSEA = .075.

Structural model. The ICF structural model was the same as at T1 and was a good fit to the data, Satorra-Bentler $\chi^2(13) = 29.81$, $p = .005$; NNFI = .96, CFI = .98, RMSEA = .08, AIC = 3.81. Impairment strongly predicted activity limitation ($\beta = .72$) and according to the R^2 value, accounted for 52% of its variance.

Time 2 (Postsurgery): TPB Model

Measurement model. The TPB measurement model was the same as at T1 and was an excellent fit to the data, Satorra-Bentler $\chi^2(24) = 42.61$, $p = .011$; NNFI = .98, CFI = .98, RMSEA = .06. Standardized residuals were small and normally distributed.

Structural model. The TPB structural model was the same as at T1 and is shown in Figure 3 with fit indices. The model was an excellent fit to the data, with 69% of the variance in activity limitation accounted for by intention and PBC, and 85% of the variance in intention accounted for by PBC. Greater PBC significantly and strongly predicted reduced activity limitation ($\beta = -.67$), but intention was not significantly predictive ($\beta = -.17$). However, PBC strongly predicted intention ($\beta = .92$).

Time 2 (Postsurgery): Integrated Model

The integrated measurement and structural models were the same as at T1. The structural model and fit indices are displayed in Figure 4. The model was a good fit to the data according to these indices and accounted for 82% of the variance in activity limitation, with 85% of the variance in intention and 24% of the variance in PBC accounted for by their predictors. Impairment predicted activity limitation ($\beta = .42$), and PBC predicted reduced activity limitation ($\beta = -.42$) but intention was not significantly predictive ($\beta = -.22$). Impairment predicted reduced PBC ($\beta = -.49$) but not intention ($\beta = .03$). However, PBC strongly predicted intention ($\beta = .94$). PBC mediated significantly between impairment and activity limitation (standardized indirect coefficient = .30, $p < .05$), such that greater impairment predicted worse PBC, which in turn predicted more severe activity limitation.

Discussion

According to Johnston (1996), integrating biomedical constructs from the WHO model of disability (such as impairment) and psychological constructs from theories of behavior (such as control cognitions) should explain disability better than a biomedical or behavioral model alone. Our findings support this. Replicating Dixon et al.'s (2008) study, we tested a model integrating TPB proximal determinants of behavior with impairment from the ICF, as well as impairment-only (ICF) and TPB models, to explain activity limitation in presurgery joint replacement patients.

Although all models predicted activity limitation, suggesting that biomedical and psychological variables contribute to activity limitations, the integrated model explained more variance and fitted better. That the direct relationship between impairment and activity limitation was significant even in the integrated model suggests that both biomedical and psychological variables need to be considered for a full understanding of the determinants of disability. Impairment also predicted PBC, which in turn predicted activity limitation, with a significant mediation effect. However, intention was not predicted by impairment and was not predictive of activity limitation. These results are very similar to those of Dixon et al. (2008), and the replication of positive findings for

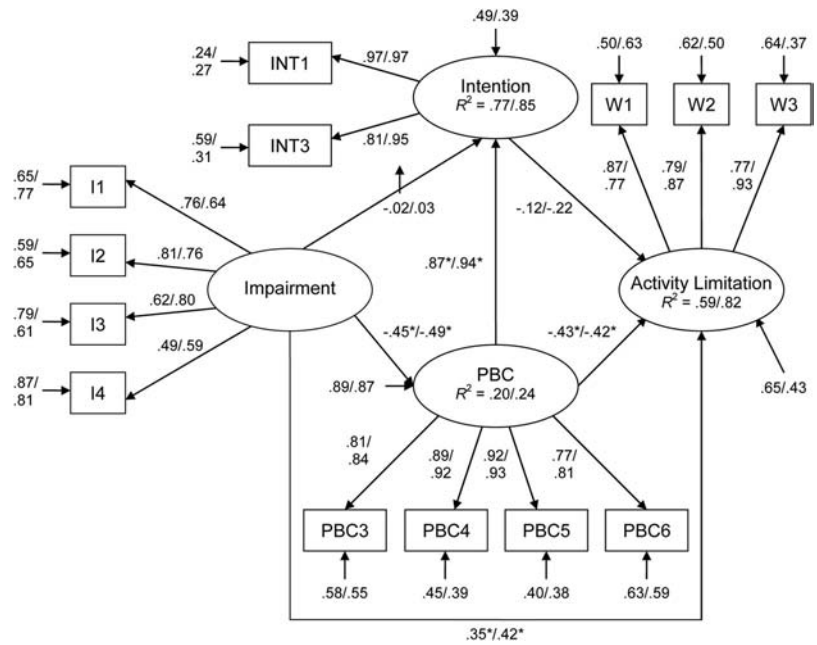

Figure 4. INT = intention; W = walking; I = impairment; PBC = perceived behavioral control. Standardized coefficients for integrated model at Time 1 (T1) and T2. First value presented relates to T1, while second relates to T2 (i.e. T1/T2). Fit indices at T1: Satorra-Bentler $\chi^2(59) = 185.67$, $p < .001$, nonnormed fit index (NNFI) = .93, comparative fit index (CFI) = .95, root-mean-square error of approximation (RMSEA) = .08, (Akaike's information criterion) AIC = 67.67. Fit indices at T2: Satorra-Bentler $\chi^2(59) = 98.69$, $p < .001$; NNFI = .97, CFI = .98, RMSEA = .05, AIC = −19.31. $^* p < .05$.

their models with these new data adds support for Johnston's (1996) arguments. It is important to note that similar findings from this replication indicate that the support previously found for these relationships is unlikely to be due to chance.

We then extended Dixon et al.'s tests to 1 year after surgery, when impairment and activity limitation were significantly less although not eliminated. Results were similar to before surgery, except that all models accounted for more variance in activity limitation and the integrated model predicted a very large proportion of the variance (82%) in activity limitations. It appears that these variables give a good account of activity limitations after surgery and may suggest that the psychological constructs are stronger determinants of activity limitation after surgery compared to before; the correlations of activity limitations with PBC and intention are substantially greater after surgery than before. The models may fit better after surgery because other variables may operate before surgery, which were not hypothesized. Alternatively, the models may predict more efficiently due to better measurement; each measurement model shows improved fit indices on the second occasion. This improved measurement might be due to (a) loss of 99 participants may have improved the coherence of the measures, (b) increased variance observed in the impairment measure strengthening relationships, (c) participants responding more coherently due to practice with the items or due to intervening experiences associated with their surgical care, or (d) greater clarity in making judgments about "half a mile" rather than 100 yards, resulting in greater coherence of measures.

After surgery, activity limitation was still predicted significantly by impairment (ICF model) and PBC (TPB model), indicating that these models provide a good base for beginning to understand disability. However, the integrated model predicted the most variance in activity limitation, suggesting that combining elements of both models may provide a fuller understanding of its determinants. Therefore, as well as replicating and extending Dixon et al.'s (2008) results, ours are also consistent with the previous findings discussed in the introduction.

Evaluating the Integrated Model

The integrated model at both time points explained more variance in activity limitations while being less parsimonious than the others. Before surgery, it accounted for 24% more variance than the ICF model and 11% more than the TPB model, while in Dixon et al.'s study it accounted for an extra 29% and 9%, respectively. After surgery, the integrated model accounted for an extra 30% and 13%, respectively. These reliable increments in explanatory power suggest an enhanced theoretical account of activity limitations and increased opportunities for therapeutic intervention. For example, it may be possible to intervene on PBC to alter activity limitation, even if impairment is currently untreatable.

Our findings support both a biomedical and behavioral viewpoint of the determinants of disability but suggest that neither provides a full explanation on its own. However, as Dixon et al. (2008) found, intention did not predict activity limitation nor was it predicted by impairment as PBC was, with Schröder et al. (2007) reporting a similar finding. This may be because the measures lack precise correspondence with the measures of behavior or because walking limitation is not determined by motivational variables

such as intention; Ajzen (1991) argued that for each behavior a different pattern of TPB variables may be predictive.

However, in a recent parallel study testing similar theoretical models with a sample of community dwelling adults, Dixon, Johnston, Elliot, and Hannaford (in press) found that both PBC and intention were significantly predictive of walking behavior. Similar results were found for participants with chronic pain. This suggests that while intention does not appear to be important in determining activity limitations in those having joint replacement surgery, it is relevant for other populations and should be retained in the integrated model.

Implications for Understanding and Managing Disability

Our data indicate that while impairment may have determined the physical limits of what participants could do, within those limits PBC determined (even if partially) what they actually did. It seems as if the participants, faced with limited resources for walking as a result of their impairment, allocated effort to walking based on what they believed was possible for them. This supports Johnston's (1996) integrated model. The TPB (Ajzen, 1991) proposes that individuals with low PBC tend not to attempt a behavior because they believe that they cannot perform it successfully. In contrast, an individual with higher PBC may attempt the behavior, be less likely to give up, and find (perhaps after more than one attempt) that they are successful. The difference between these persons may be in effort expended and persistence, as Bandura (1977) has argued for self-efficacy.

Although care must be exercised in causal interpretations of these results, they suggest the possible benefits of reducing impairment or enhancing control cognitions to alleviate activity limitations, both approaches in use in clinical practice. Our results suggest processes by which existing interventions without a defined theoretical foundation may operate. They also suggest why improvements in disability or functioning may occur even when medical treatment does not have the expected effect on body structure and function. For example, chronic pain patients in Flor et al.'s (1992) review, who had improved functioning in everyday tasks despite little change in pain after multidisciplinary treatment, may have undergone changes in their perceived control. Interventions to enhance perceived control have been shown effective in reducing activity limitations in stroke (e.g., Johnston et al., 2007), and perceived control (as self-efficacy) has been targeted in the self-management groups of Lorig and her colleagues (Lorig et al., 1989; Lorig & Holman, 1993), who found that beneficial effects of attendance at their programs were not explained by increased exercise but by greater self-efficacy.

The TPB, as one foundation of Johnston's (1996) model, has been found to predict many behaviors in a wide range of populations including those who are ill (e.g., Armitage & Conner, 2000, 2001; Godin & Kok, 1996). Therefore, it seems reasonable that our findings may generalize to disability behaviors other than walking and to other populations. Currently, control cognitions have been found to predict activity limitations following stroke (e.g., Bonetti & Johnston, 2008), heart attack or angina (Allan, Johnston, Johnston, & Mant, 2007), and recovery from acute injuries of various kinds (Molloy, Sniehotta, & Johnston, 2009).

Strengths, Limitations, and Future Directions

One strength of this study is that it shows, in a sample of adequate power for most models, that the integrated model fits the data and accounts for considerable variance—more than that accounted for by simpler models. Furthermore, this finding is reliably replicated. However, there are limitations to what can be concluded—for example, other (untested) models may also be a good or better fit. In addition, although Johnston's (1996) model proposed causal relationships, because of our correlational data we cannot conclude that the relationships are causal. Experimental designs (e.g., Fisher & Johnston, 1996a) and randomized controlled trials (e.g., Johnston et al., 2007) are superior tests of causality.

The limited operationalization of the ICF constructs also restricts our conclusions. Other forms of impairment (e.g., joint stiffness) may have contributed to walking limitation, and participants may have experienced other forms of activity limitation (e.g., difficulty using stairs, bending down, and lifting objects). Future research testing this model may benefit from a multicomponent approach to these constructs, perhaps using the *ICF* core sets for each diagnosis. Johnston (1996) also proposed integrating biomedical constructs with Bandura's (1986) social–cognitive theory. This is more complex than the TPB but makes similar propositions although without the construct of intention. There is scope for future research to examine the role of Bandura's constructs in the model more fully. In addition, a fuller understanding of disability may be obtained by examining the ICF concept of participation restriction in integrated terms. Although this is not currently part of the integrated theory, it is a key part of the experience of disability and because, like the other ICF concepts, it is connected to environmental and personal factors, may be associated with psychological processes. This remains to be explored in future work.

Finally, cross-sectional data from large samples capture the characteristics of many individuals at a single moment. These existing findings primarily relate to individual differences, that is, that people who have worse impairment and PBC tend to experience greater activity limitation. Is it also the case that at those times in a person's life when impairment and perceived control are worse, activity limitation is more severe? To know this is essential when designing interventions and can be examined by collecting regular observations over time (Borckardt et al., 2008), for example using single-case designs (Morgan & Morgan, 2001).

Conclusion

Our findings clearly replicate those of Dixon et al. (2008) for orthopedic patients before surgery as well as after a surgical change in body structure and function. It is therefore unlikely that Dixon et al.'s original findings simply capitalized on chance. They add to a growing body of knowledge supporting Johnston's (1996) integrated model, suggesting that disability in chronic illness is not just the product of characteristics of the body, but partly of the mind as well. Further research is required to test the causal relationships in the model, to investigate applicability within individuals, and to evaluate the model in other populations. Our findings suggest there may be hope for easing the burden of locomotor disability by targeting control cognitions—because, perhaps with a little help, one can change one's mind.

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