This is the post-print of the article Bernardes SF, Brandão T, de Matos MO, Ferreira-Valente A. Social support for functional dependence, activity patterns, and chronic pain outcomes: A cross-lagged mediation panel study. Health Psychol. 2024 Mar 21. doi: 10.1037/hea0001370. Epub ahead of print. PMID: 38512212.

Social support for functional dependence, activity patterns and chronic pain outcomes: A cross-lagged mediation panel study.

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Abstract

Objective: Received social support undermining engagement in life activities of individuals with chronic pain (e.g., solicitousness, support for functional dependence) is consistently correlated with worse physical functioning, pain severity and disability. Whether such responses lead to worse pain outcomes (operant model of pain) or the latter lead to more supportive responses undermining activity engagement (social communication and empathy models of pain) is unknown, given the lack of cross-lagged panel studies. Furthermore, the mediating role of activity patterns in such relationship over time is entirely unclear. This study aimed to bridge these gaps. ***Methods:*** This was a three-month prospective study with three waves of data collection (T1-T3; six-week lag in-between), including 130 older adults (71% women; M_{age}=78.26) with musculoskeletal chronic pain attending day-care centers. At every time point, participants filled out self-report measures of staff social support for functional dependence, activity patterns, physical functioning, pain severity and interference. Scales showed good/very good test-retest reliability (ICC=.74-.96) and internal consistency (all α>.90). ***Results:*** Parsimonious cross-lagged panel mediation models showed the best fit (χ^2/df<2.44; CFI>.96; GFI>.93; RMSEA<.09). Bidirectional effects were found over time, but poorer pain outcomes at T1 (higher pain severity/interference, lower physical functioning) more consistently predicted higher social support for functional dependence than vice versa. Poorer pain outcomes (T1) predicted more avoidance/less overdoing (T3), via increased received support for functional dependence (T2). ***Conclusion*:** Further research on the cyclical relationships between the study variables across chronic pain trajectories is needed to harness the power of interpersonal relationships in future self-management interventions.

Public significance statement

Older adults with worse chronic musculoskeletal pain outcomes report receiving from daycare centers' staff more support promoting their functional dependence; in turn, the latter also slightly predicts poorer pain outcomes and less activity engagement over time. Formal caregivers are encouraged to notice the role such interpersonal supportive exchanges in older adults' chronic adaptation processes.

Keywords: chronic pain, received social support, activity patterns, cross-lagged panel design, older adults

Chronic disease self-management is a complex, day-to-day and (often) life-long behavioral change process, which may greatly benefit from the help of others (Martire & Helgeson, 2017). However, harnessing the power of social support interactions (*i.e*., received social support) is no simple deed, as their effectiveness varies across contexts (Rafaeli & Gleason, 2009). Under certain circumstances, even the most well-intentioned supportive actions may hamper self-management processes and, ultimately, chronic illness adjustment (Martire & Helgeson, 2017; Thompson et al., 2022). Thus, although social support is often described by individuals with chronic diseases as an important resource (Kostova et al., 2014), understanding its pitfalls may be vital to the development of interventions that unlock the potential of interpersonal relationships to promote effective chronic disease self-management and optimal illness adjustment (Thompson et al., 2022). This article contributes to such endeavor while focusing on a major worldwide public health problem- chronic pain.

Received Social Support and Chronic Pain Maladjustment

Chronic pain is pain that recurs or persists beyond 3 months, lacking a survival functional value (Treede et al., 2019). Chronic (musculoskeletal) pain is one of the leading causes of years lived with disability worldwide (Vos et al., 2020), affecting the lives of one in five U.S.A. (Yong et al., 2022) and European citizens (Breivik et al., 2006). Given that the prevalence and disabling effects of chronic pain increase with age, and that the ageing rate of western societies is increasing dramatically (WHO, 2015), the societal burden of chronic pain is set to escalate. Therefore, promoting life-long effective chronic pain self-management is vital for individuals, families, and socioeconomic sustainability.

A widely supported assumption of current psychosocial theoretical models on chronic pain states that individuals' engagement in meaningful physical and social activities despite pain is a major protective factor of pain persistence and poor chronic pain adjustment (Turk, 2002; Vlaeyen & Linton, 2012). Therefore, activity engagement despite pain is a vital self-management task that is often the focus of psychological interventions (Sturgeon, 2014). Pain-related received social support, *i.e*., self-reports of supportive actions received by individuals when they communicate their (chronic) pain

(Bernardes et al., 2017a; Jensen et al., 2011; Leonard et al.,2006), may vary in the extent to which they promote activity engagement. Although some evidence suggests that others (e.g., caregivers, spouses, friends) may be important resources towards optimal adjustment to chronic pain by facilitating individuals' well-behaviors (Bernardes et al., 2017a; Jensen et al., 2011; Leonard et al., 2006) and promoting their functional autonomy (Matos et al., 2016, 2017b), researchers have paid more attention to helping actions that may undermine adults' activity engagement and hinder chronic pain adjustment.

A comprehensive review of informal pain-related social support (Bernardes et al., 2017a) showed that 90% of the studies focused on others' solicitousness, *i.e.*, overattentiveness to pain behaviors and provision of instrumental assistance by taking over individuals' chores (Newton-John, 2002). Drawing upon the operant model of pain (Fordyce, 1976), most of these studies hypothesized that others' solicitousness, by positively reinforcing pain behaviors, predicted poorer pain outcomes. Seminal observational studies in laboratory settings, conducted by Romano and colleagues (1992, 1995), provided strong empirical support to this hypothesis. Compared to healthy couples, observed spouse solicitous responses more often preceded (non-)verbal pain behaviors of individuals with chronic pain, while they collaborated in a series of routine household activities (Romano et al., 1992). Furthermore, the sequence of spouse solicitousness in response to non-verbal pain behaviors predicted physical dysfunction among more depressed individuals with chronic pain (Romano et al., 1995). Although these studies did not assess received social support, more recent cross-sectional findings in clinical settings show a consistent positive association between received spousal solicitousness and insomnia severity, increased pain behaviors, pain severity, pain disability and poorer physical and psychological functioning (Bernardes et al., 2017a; Jensen et al., 2011; Leonard et al., 2006). A similar pattern of findings was found in studies partially drawing upon seminal work on dependency support in advanced ages (Baltes, 1998; Baltes & Whal, 1992), which contended that the impact of received social support on pain adjustment depends on the extent to which it promotes functional autonomy vs. dependence (Matos & Bernardes, 2013; Matos et al. 2015, 2016). Specifically, older adults in formal care settings who reported higher received social support for functional dependence from staff (i.e., supportive actions that replaced them in their activities and/or promoted the avoidance of social and physical activities when in pain) also reported higher pain disability.

Prospective studies, however, show a less consistent pattern of findings. Some studies indeed confirm that higher solicitousness or higher social support of functional dependence predict increases in fibromyalgia tender points (Schmaling et al., 2020), pain disability (Matos et al., 2017a; Hanley et al., 2004; Jensen et al., 2002), depression (Jensen et al., 2002), functional limitations and decreases in activity levels (Hemphill et al., 2016). However, a few studies showed that solicitousness either did not predict pain outcomes over time (Van Koulil et al., 2010; Wilson et al., 2017) or predicted decreases in disease activity (Griffin et al., 2001) and increases in pain acceptance (Söderlund et al., 2018).

This inconsistent pattern of prospective findings in clinical or naturalistic settings suggests that the relationship between such supportive actions and pain maladjustment across time (i.e., temporal relationships) needs further investigation. More evidence is needed on the extent to which such types of received social support may indeed predict worse chronic pain adjustment over time. Furthermore, it may also be important to consider that worse pain outcomes may drive others towards helping actions that promote activity disengagement. Indeed, the Social Communications Model of Pain (Craig, 2009; Hadjistavropoulos et al., 2011) and the Empathy Model of Pain (Goubert et al., 2005) postulate that higher availability of observable cues that signal pain (pain behaviors) facilitate pain decoding processes and increase the likelihood of eliciting (empathic) responses to pain from observers. Indeed, Romano et al.'s observational studies (1992) showed that, compared to healthy couples, observed spouse solicitous responses more often followed pain behaviors of individuals with chronic pain. Therefore, as poorer pain outcomes (e.g., pain disability) often come along with increased pain behaviors, it is reasonable to expect that these will elicit more supportive responses. Despite scant, a few prospective findings support this contention. For example, a daily diary study (Wilson et al., 2013) showed that (non)verbal pain expressions of women with osteoarthritis, as perceived by spouses, independently predicted same-day spousal solicitous and empathic responses.

Investigating the potential bidirectional relationship over time between received social support that promotes activity disengagement and chronic pain maladjustment is vital to the development of effective self-management interventions that wish to consider the role of interpersonal relationships. Nonetheless, the lack of cross-lagged panel studies in the field has preempted such investigation. Therefore, the first main aim of this 3-month cross-lagged panel study with older adults with chronic musculoskeletal pain was to investigate the potential bidirectional relationship over time between formal social support (i.e., received from staff of formal care institutions) for functional dependence and chronic pain outcomes.

Drawing upon the previously mentioned theoretical models, and assuming that their predictions are not mutually exclusive, we hypothesized that there would be a bidirectional relationship over time between formal social support for functional dependence and poorer chronic pain outcomes. More specifically, the hypotheses (H_s) were: ($H1_a$) higher received formal social support for functional dependence would subsequently predict poorer chronic pain outcomes, *i.e*., higher pain severity, pain interference, and lower physical functioning; and ($H1_b$) poorer chronic pain outcomes would subsequently predict more received formal social support for functional dependence.

The Mediating Role of Activity Patterns

The second aim of this study was to investigate the extent to which the potential reciprocal relationship between social support promoting activity disengagement and chronic pain outcomes over time was mediated by individuals' activity patterns. The mediating processes that account for the relationship between pain-related social support and chronic pain outcomes have been under investigated, as most studies in the field have sought to study their direct associations (Bernardes et al., 2017a). Existing studies investigating such mediating mechanisms mainly focused on cognitive factors, such as pain catastrophizing, self-efficacy, and pain-related fear (Rosen et al., 2013; Matos et al., 2017a). However, behavioral factors, such as activity patterns, which are often targeted by self-management and rehabilitation interventions as they are intimately related to activity engagement

(Nielson et al., 2013), have rarely been investigated. Activity patterns are consistent patterns of behavior that reflect how individuals organize their daily occupations (Bendixen et al., 2006). Chronic pain often changes such activity patterns, which ultimately play an important role in pain persistence and adjustment (Cane et al., 2018). Traditionally, three main types of activity patterns have been identified among individuals with chronic pain (Andrews et al., 2012; Cane et al., 2013): 1) Avoidance of (physical) daily activities to minimize pain; 2) Persisting on activities despite pain; and 3) Pacing, *i.e.*, regulating the level and/or rate of activities by slowing down and/or breaking down activities into smaller tasks. A meta-analysis (Andrews et al., 2012) showed that activity avoidance is consistently associated with higher pain severity and worse physical and psychological functioning, whereas pacing is associated with better chronic pain outcomes. Findings on persistence were ambiguous; if mere persistence with activities despite pain was associated with positive outcomes, overactivity was associated with worse outcomes.

The extent to which such activity patterns influence or are influenced by others' responses to pain is greatly under investigated. Some inconsistent findings show that solicitousness did not predict activity engagement one year after whiplash trauma rehabilitation (Söderlund et al., 2018) but it was associated with lower engagement in household activities, and general activity of US military with chronic pain (McGeary et al., 2016). Albeit scarce, evidence suggests that pain-related responses may potentially influence and/or be influenced by activity patterns, but this contention remains to be tested.

Theoretical predictions on the functional role of received social support (Schwarzer & Knoll, 2007), suggest that it may influence health outcomes via coping responses. Considering activity patterns as behavioral pain-related coping responses, we could hypothesize ($H2_a$) that social support for functional dependence predicts more avoidance and/or less pacing and/or persistence, hence accounting for worse chronic pain outcomes (i.e., higher pain severity, interference, and lower physical functioning). Conversely, as, in theory, worse pain outcomes may lead to lower activity engagement (Vlaeyen & Linton, 2012), and coping efforts may shape others supportive responses (Schwarzer & Knoll, 2007), we could also hypothesize that ($H2_b$): worse chronic pain outcomes predict higher avoidance and/or lower pacing and/or persistence, hence, accounting for more formal social support for functional dependence.

Method

Study Design and Participants

This is a secondary analysis of data collected from a larger three-month prospective study aiming at investigating the role of formal social support for functional autonomy and dependence in older adults' chronic pain adjustment (Matos et al., 2016, 2017a,b). This study had three waves of data collection (T1, T2 and T3) with a six-week lag in-between, and included a total of 170 older adults: (1) with chronic musculoskeletal pain (*i.e*., constant or intermittent pain, for at least 3 months, in muscles, joints, ligaments, tendons and/or bones), (2) attending day-care centers in and around Lisbon for at least 6 months, (3) not cognitively impaired (based on clinical staff assessments) and (4) able to read and write autonomously.

For the present study, we excluded participants who did not complete one or more waves of assessment (n = 38) and who reported "0" pain intensity at T1 (n = 2). Thus, a total of 130 participants were included in the present study (M_{age} = 78.26; *SD* = 9.23; min = 50; max = 99; 71% female). Participants reported an average of 5 years of formal education (*M* = 4.98; *SD* = 2.77; min = 2; max = 20). Around 59% were widowed (n = 77), 24% were married (n = 31), 11% were divorced (n = 14) and 6% were single (n = 8). Most older adults lived alone (54%) and attended the day-care center for a duration of six months to 30 years (*M* = 4.56 years; M*dn* = 2; *SD* = 5.78). All the participants reported experiencing musculoskeletal chronic pain on one (66%) to five (2.3%) pain locations, with a duration of three months to 52 years (*M* = 7.69 years; M*dn* = 4; *SD* = 10.46) and all reported having experienced pain in the previous week. The most common pain locations were joints (40%), bones (26%), muscles (19%), tendons or ligaments (4%). Around 14% of participants were medically advised not to exercise, 45% experienced chest pain or dizziness frequently, and 20% had high blood pressure.

Measures

Formal Social Support for Functional Dependence.

Formal social support for functional dependence was assessed using the Perceived Promotion of Dependence (PPD) subscale of the revised Formal Social Support for Autonomy and Dependence in Pain Inventory (FSSADI_PAIN; Matos et al., 2015). The FSSADI_PAIN is a parsimonious, valid, and reliable self-report measure of received social support from staff of formal care institutions to promote functional autonomy/dependence. It is composed of two subscales: perceived promotion of (functional) autonomy (4 items) and perceived promotion of (functional) dependence (4 items). In this study, we have only used the subscale of perceived promotion of dependence (PPD), which includes the following items: *When I am in pain, the employees at this institution…: …bring me everything so that I don't need to move; …advise me to stop doing whatever I am doing*; *…tell me that I need help from others to cope with my pain*; *…tell me not to push myself when I feel unable of handling certain issue*. Items were rated on a 5-point Likert scale ranging from 0 (*not at all frequent*) to 5 (*extremely frequent*). The PPD score was obtained by calculating the mean of the four items. The higher the score the higher the PPD. In the present sample, this subscale showed very good internal consistency at all time measurement points (α^{T1} = .94, α^{T2} = .96, and α^{T3} = .95) and a high temporal stability across the time measurements (ICC=.85; 95%CI [.801, .891]).

Pain Severity and Interference

Pain severity and interference were measured using the respective subscales of the Portuguese version of the Brief Pain Inventory (BPI; Azevedo et al., 2007). The pain severity subscale (4 items) assesses pain at its *worst*, *least*, *average*, and *now* (current pain) using four items that are rated on a 10-point Likert scale ranging from 0 (no pain) to 10 (the worst possible pain); the higher the score the higher the pain intensity. In the present sample, this subscale showed very good internal consistency at all time measurement points (α^{T1} = .88, α^{T2} = .89, and α^{T3} = .92) and good temporal stability across the latter (ICC= .74 (95%CI [.655, .810]).

Seven items measure pain interference on seven daily activities namely *general activity*, *mood*, *walking ability*, *normal work*, *social relationships*, *sleep*, and *enjoyment of life*. Items are rated on a 10-point Likert scale ranging from 0 (*no interference*) to 10 (*interferes completely*). The pain interference score was obtained by calculating the mean of the seven items. The higher the score the higher the pain interference. In the present sample, this subscale showed very good internal consistency at all time measurement points (a^{T1} = .94, a^{T2} = .95, and a^{T3} = .95) and high temporal stability across the latter (ICC=.84 (95%CI [.789, .884]).

Physical Functioning

Self-reported physical functioning was assessed using the physical functioning subscale of the Portuguese version of the Medical Outcomes Study - Short Form 36v2 (SF-36; Ferreira, 2000). This subscale is composed by 10 items, but only the 5 items that were relevant for the daily context and routines of older adults in day care centers were used. These items assessed participants' abilities to perform the following daily physical activities: a) moving a table, pushing a vacuum cleaner, bowling, or playing golf; b) climb one flight of stairs; c) bend, kneel, or stoop; d) walk one block; e) bathe or dress. Items were rated on the following scale: 1 (yes, limited a lot), 2 (yes, limited a little) and 3 (no, not limited at all). Following the guidelines of Ferreira (2000), items were transformed into a final score that ranged from 0 (lowest disability) to 100 (highest disability). The higher the score the higher the self-reported physical functioning. In the present sample, this scale showed very good internal consistency at all time measurement points (α^{T1} = .93, α^{T2} = .94, and α^{T3} = .94) and high temporal stability across the latter (ICC=.92 (95%CI [.895, .943]).

Patterns of Activity

Patterns of activity were measured using the Portuguese version of the Patterns of Activity Measure-Pain (POAM-P; Vieira et al., 2012). This scale assesses three patterns of activities (30 items): avoidance (10 items, e.g., "*There are many activities that I avoid because they flare up my pain*"),

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overdoing (10 items, e.g. "*When I'm doing an activity, I don't stop until it is finished*"), and pacing (10 items, e.g. "*I go back and forth between working and taking breaks when doing an activity*"). Items were rated on a 5-point Likert scale ranging from 0 (*not at all*) to 4 (*all the time*). Scores for each subscale were obtained by summing the respective items. The higher the score the more frequent the activity pattern. Noteworthy, despite its name, most items of the overdoing scale assess task persistence as opposed to excessive persistence (Kindermans et al., 2011).

Given the scant information about the psychometric properties of this scale for the Portuguese population, a confirmatory factor analysis (CFA) was conducted and confirmed the original factor structure. However, 2 items from the overdoing subscale were eliminated (item 30 and item 23) because they presented factor loadings below .40, resulting in an improvement in the model fit (c^2/df = 2.42; CFI = .91; TLI = .90; RMSEA = .09, $p < .001$). The internal consistency of the subscales was very good at all measurement points (avoidance: α^{T1} = .97, α^{T2} = .97, and α^{T3} = .96; overdoing: α^{T1} = .93, α^{T2} = .91, and α^{T3} = .92; pacing: α^{T1} = .94, α^{T2} = .93, and α^{T3} = .94). These subscales also showed high temporal stability: ICC = .96 (95%CI [.947, .971]) for avoidance, .95 (95%CI [.930, .962]) for overdoing, and .93 (95%CI [.910, .951]) for pacing.

Procedure

This study was approved by the Ethics Committee of Iscte (07/2017). A total of 11 day-care centers of the Lisbon metropolitan area that belonged to non-profit organizations were contacted to participate in this study. Like in many other countries (Orellana et al., 2020), Portuguese day-care centers provide social services to prevent retired older adults' social isolation and loneliness, support their continued independence and integration in their socio-familial environment, and support informal caregivers (e.g., to have a break and/or keep employed). To do so, several services are provided during the day, such as meals, laundry, transportation, personal hygiene and social/cultural (e.g., organized outings to the cinema, theatre, or museum), and recreational activities (e.g., organized vacation programs). These services are managed by a technical director (psychologist or social worker), and often include a sociocultural animator, personal care aids, a cooking team, and a driver (Ministério do Trabalho, da Solidariedade e da Segurança Social [MTSSS], 2019).

A protocol containing information regarding the aim of the study, procedures, potential risks and benefits of individuals' participation and research outcomes were sent to all 11 institutional boards. Only 9 institutions accepted to participate in this study. The clinical staff of the participating institutions helped with the recruitment process by identifying potential participants who were users of the day-care center for at least 6 months, had not been previously diagnosed with dementia or other cognitive impairments, and were able to read and write autonomously. Afterwards, potential participants were individually screened by one member of the research team (MM) to identify the presence of chronic musculoskeletal pain. These users were invited to participate in the study. Those who agreed to participate signed a written informed consent, where confidentiality and pseudonymization of the data was guaranteed. No incentives or compensations were offered to participants or institutions. At baseline, sociodemographic (sex, age, marital status, education, profession before retirement, time at the institution) and clinical information was collected (type of pain, pain duration, pain location, pain causes). At all 3 time points, paper-and-pencil measures to assess pain severity and interference, physical functioning, perceived promotion of dependence, and patterns of activities were completed. To facilitate the participation of older adults with low levels of education and/or visual impairments, the data collection protocols were administered via face-to-face individual structured interviews by MM, in a quiet room of the institution. On average, each data collection session took about 35 minutes. After each data collection session, data was pseudonymized; codes were used to match participants' data across the three waves of data collection. At T3, participants and institutions were thanked and debriefed.

Data analysis

First, descriptive statistics (means, standard deviations, and frequencies) and Pearson correlations were calculated for all study variables, at every measurement point, in SPSS 28.0 software package. Second, t-tests and correlations were used to test the associations between the study variables and socio-demographic/clinical variables (sex, age, education, pain duration, time at institution), using a Bonferroni correction (0.5/105) that set *p* at .004. Third, to test the study hypotheses, cross-lagged panel mediation analyses (Kessler & Greenberg, 1981) were conducted using structural equation modelling (SEM) with AMOS 24.0 software package. These analyses tested the temporal bidirectional relations between pain severity/interference, physical functioning, PPD, and patterns of activities across the three time points.

In the cross-lagged panel models, the variables at T1 were conceptualized as intercorrelated, as were the disturbance (or error) terms associated with the observed variables. Autoregressive paths (i.e., paths that link an observed variable measured later with the same variable measured earlier, e.g., PPD at T1 – PPD at T2; PPD at T2 – PPD at T3) provide information about the relative stability of the construct, with higher values indicating greater stability. Cross-lagged paths (i.e., paths between different variables at different time points, e.g., the path between PPD at T1 – pain interference at T2) provide information about temporal relationships.

For pain severity, interference, and physical functioning, three models were tested: model 1 - a baseline model with autoregressive effects only; model 2 - the autoregressive effects plus the full cross-lagged effects, as to test if adding cross-lagged paths improved the model fit and its explained variance beyond the one associated with the stability effects; model 3 - model 2 without the non-significant paths, as to find the most parsimonious model. These models were compared using various fit indices: χ^2/df statistic (< 5), the comparative fit index (CFI) (> .90), the goodness of fit index (GFI) (> .90), and the root mean square error of approximation (RMSEA) (<.08) (Hooper et al., 2008) – and using the Akaike information criterion (AIC) difference (smaller values mean better fit; Lian et al., 2014).

To assess mediations, we examined indirect effects using bootstrap resampling procedures since they are more accurate to identify confidence intervals, allow dealing with non-normality and avoid exceeding nominal Type I error rates (MacKinnon et al., 2004). The bias-corrected bootstrap 90% confidence interval (CI) for the unstandardized effects was used since it was considered the more adequate method to accurately estimate indirect effects (MacKinnon et al., 2004) and bootstrap estimates were based on 5000 bootstrap samples, as commonly done in previous studies (Ledermann et al., 2011).

Results

Descriptive Statistics and Correlations between Study Variables

Descriptive statistics and correlations between all variables are shown in Table 1. Most of the model variables were significantly associated at the same time and at different time points. Only pacing was not significantly associated with any of the remaining study variables and for that reason it was not included in the cross-lagged panel analyses. Furthermore, most sociodemographic, and clinical variables were not significantly associated with the main study variables. The only exception was participants' sex, which was significantly associated with overdoing at T1 (p <.001); women reported higher overdoing than men at T1. Thus, sex was entered as a covariate in the cross-lagged models that included overdoing.

[INSERT TABLE 1 AROUND HERE]

Cross-Lagged Panel Analysis for Pain Severity

Fit indices and indirect effects of the cross-lagged models with PPD, activity patterns (overdoing and avoidance) and pain severity are presented in Table 2. For both patterns of activity, the most parsimonious models (*i.e*., without the non-significant paths) presented the best fit. Regarding avoidance, pain severity at T1 predicted PPD at T2 ($ß$ = .14, p < .05), PPD at T2 predicted avoidance at T3 ($ß$ = .09, p < .05) and pain severity at T3 ($ß$ = .18, p < .05). Aside from the autoregressive indirect effects of PPD and activity avoidance, three significant cross-lagged indirect effects were found (Table 2): (1) more PPD at T1 predicted more PPD at T2, which in turn predicted more avoidance at T3; (2) pain severity at T1 predicted more PPD at T2, which in turn predicted more PPD at T3; and (3) pain severity at T1 predicted more PPD at T2, which in turn predicted more avoidance at T3 (see Figure S1 in the supplementary files).

[INSERT TABLE 2 AROUND HERE]

As for overdoing (controlling for sex), pain severity at T1 predicted more PPD at T2 ($ß$ = .13, p < .05), which predicted less overdoing at T3 ($ß$ = -.12, p < .05). Furthermore, more PPD at T2 predicted more pain severity at T3 ($ß$ = .17, p < .05). Aside from the autoregressive indirect effects of PPD, overdoing and pain severity, four indirect cross-lagged effects (Table 2) were significant: (1) more pain severity at T1 predicted more PPD at T2, which in turn predicted less overdoing at T3; (2) more pain severity at T1 predicted more PPD at T2, which in turn predicted more pain severity at T3; (3) more pain severity at T1 predicted more PPD at T2, which in turn predicted more PPD at T3; and (4) more PPD at T1 predicted more PPD at T2, which in turn predicted less overdoing at T3 (see Figure S2 in the supplementary files).

Cross-Lagged Panel Analysis for Pain Interference

Fit indices and the indirect effects of the cross-lagged models with PPD, activity patterns and pain interference are presented in Table 3. For both patterns of activities (i.e., avoidance and overdoing), the most parsimonious models presented the best fit. Regarding avoidance, PPD at T1 predicted avoidance at T2 ($ß$ = -.08, p < .05) and PPD at T2 predicted avoidance at T3 ($ß$ = .12, p < .01). Pain interference at T1 predicted PPD at T2 ($ß$ = .26, p < .001), and pain interference at T2 predicted PPD at T3 ($ß$ = .15, p < .05). Only three indirect cross-lagged effects were significant: (1) more pain interference at T1 predicted more PPD at T2, which in turn predicted more avoidance at T3; (2) more pain interference at T1 predicted more PPD at T2, which in turn predicted more PPD at T3; and (3) more pain interference at T1 predicted more pain interference at T2, which in turn predicted more PPD at T3 (see Figure S3 in supplementary files).

[INSERT TABLE 3 AROUND HERE]

Regarding overdoing (controlling for sex), PPD at T1 predicted more overdoing at T2 ($ß$ = .09, p < .05) but PPD at T2 predicted less overdoing at T3 ($ß$ = -.14, p < .05). Pain interference at T1 predicted more PPD at T2 ($ß$ = .26, p < .001) and less overdoing at T2 ($ß$ = -.10, p < .05). Pain interference at T2 predicted more PPD at T3 (*ß* = .15, $p < .05$). Three indirect cross-lagged effects were significant: (1) more pain interference at T1 predicted more PPD at T2, which in turn predicted less overdoing at T3; (2) more pain interference at T1 predicted more PPD at T2, which in turn predicted more PPD at T3; and (3) more pain interference at T1 predicted more pain interference at T2, which in turn predicted more PPD at T3 (see Figure S4 in supplementary files).

Cross-Lagged Panel Analysis for Physical Functioning,

Fit indices and the indirect effects of the cross-lagged models with PPD, activity patterns and physical functioning are presented in Table 4. Once more, for both patterns of activities, the parsimonious models had the best fit. Regarding avoidance, more PPD at T1 predicted slightly less avoidance at T2 (*ß* = -.09, $p < .05$) but PPD at T2 predicted more avoidance at T3 (*ß* = .12, $p < .01$). More PPD at T1 predicted lower physical functioning at T2 (*ß* = -.12, $p < .05$). Better physical functioning at T1 predicted less PPD at T2 (*ß* = -.15, $p < .05$) and less avoidance at T2 (*ß* = -.10, $p < .05$). Better physical functioning at T2 predicted less PPD at T3 (*ß* = -.26, $p < .05$). Only two cross-lagged indirect effects were significant: (1) lower physical functioning at T1 predicted more PPD at T2, which in turn predicted more avoidance at T3; and (2) lower physical functioning at T1 predicted more PPD at T2, which in turn predicted more PPD at T3 (see Figure S5 in supplementary files).

[INSERT TABLE 4 AROUND HERE]

As for overdoing (controlling for sex), more PPD at T1 predicted slightly more overdoing at T2 (*ß* = .08, $p = .05$) but lower physical functioning at T2 (*ß* = -.12, $p < .05$). Better physical functioning at T1/T2 predicted less PPD at T2/T3 (*ß* = -.15, $p < .05$; *ß* = -.26, $p < .05$, respectively) and better physical functioning at T1 predicted more overdoing at time 2 (*ß* = .15, $p < .01$). More PPD at T2 predicted less overdoing at T3 (*ß* = -.15, $p < .01$). Aside from the autoregressive indirect effects of PPD and overdoing, five indirect cross-lagged effects were significant: (1) less physical functioning at T1 predicted more PPD at T2, which in turn predicted less overdoing at T3; (2) lower physical functioning at T1 predicted more overdoing at T2, which in turn predicted more overdoing at T3; (3) lower physical functioning at T1 predicted more PPD at T2, which in turn predicted more PPD at T3; (4) more physical functioning at T1 predicted more physical functioning at T2, which in turn predicted less PPD at T3; (5) less PPD at time 1 predicted more physical functioning at T2, which in turn predicted more PPD at T3 (see Figure S6 in supplementary files).

Discussion

This cross-lagged panel study investigated: (1) the temporal bidirectional relationship between formal received social support for functional dependence and older adults' chronic pain outcomes, and (2) the mediating role of pain-related activity patterns in such relationship over time.

Regarding the first aim, findings have only partially supported $H1_a$, which hypothesized that higher received social support for functional dependence would subsequently predict poorer chronic pain outcomes. More specifically, controlling for autoregressive effects, higher staff social support for functional dependence (at T1/T2) directly and respectively predicted (albeit only slightly) older adults' lower physical functioning (T2)/higher pain severity (T3) 6 weeks later. This is in line with previous prospective findings confirming that higher solicitousness or higher social support for functional dependence predicted worse pain outcomes, such as increases in pain disability (Hanley et al., 2004; Jensen et al., 2002; Matos et al., 2017a), functional limitations and decreases in activity levels (Hemphill et al., 2016). Yet, our findings more consistently supported $H1_b$, predicting that poorer chronic pain outcomes would lead to more received social support for functional dependence over time. Indeed, results showed that higher pain interference and lower physical functioning (at T1/T2), consistently and directly predicted more staff social support for functional dependence 6 weeks afterwards (at T2/T3, respectively). Pain severity at T1 also slightly predicted more support for functional dependence at T2, but this effect did not hold significance from T2 to T3. Overall, this is in line with previous experimental (Romano et al., 1995) and daily diary studies' findings (Wilson et al.,2013) showing that (non)verbal pain expressions of individuals with chronic pain predicted subsequent spousal solicitous responses.

The analysis of the indirect effects between received social support for functional dependence and pain outcomes over 3-months (via social support and/or pain outcomes at T2) showed a similar pattern of results. Received social support for functional dependence at baseline did not show any indirect effects on older adults' pain outcomes 3 months later. However, poorer pain outcomes at baseline (i.e., higher pain severity, interference, and lower physical functioning) consistently and indirectly predicted higher staff social support for functional dependence 3 months later. Such long-term indirect effects were simultaneously accounted for by: (a) the increase in received social support for functional dependence and (b) the worsening of chronic pain outcomes at T2.

In sum, over an observational period of 3 months, reciprocal effects were found between older adults' poorer pain outcomes and staff's social support for functional dependence. Nonetheless, pain outcomes at baseline (especially functional outcomes) more consistently predicted subsequent received social support for functional dependence over time than vice versa. Therefore, although our findings do not entirely rule out the predictions of the operant model of pain (Fordyce, 1976) and the theoretical assumptions underlying the role of received social support for functional dependence (Matos & Bernardes, 2013; Matos et al., 2016), they provide greater support to the predictions of social communication (Craig, 2009; Hadjistavropoulos et al., 2011) and empathy models (Goubert et al., 2005) of pain. Since the average pain duration reported by the participants was around 8 years, these findings show that at advanced stages of chronic pain trajectories, pain outcomes are more likely to drive social support responses than vice versa. This is most likely because the former show higher temporal stability (stronger autoregressive effects) and, eventually, lower malleability to change compared to the latter. It is possible that social support responses may play a higher predictive effect over chronic pain outcomes at earlier stages of the pain development trajectory, but this contention remains to be tested.

Our findings did not support our hypotheses suggesting pain-related activity patterns as mediators of the bidirectional relationship between social support for functional dependence and chronic pain outcomes over time (H2a and H2b). Nonetheless, several relevant direct and indirect effects over time involving avoidance and overdoing (but not pacing) were found. As for direct short-term effects, social support for functional dependence showed small direct effects over activity patterns, but inconsistently over time. Against our expectations, higher received support for functional dependence at baseline predicted less avoidance and more overdoing (i.e., task persistence) 6 weeks later (at T2; for pain interference and physical functioning models only). As previous studies showed that older adults prefer social support for functional autonomy than functional dependence (Bernardes et al. 2017b), these results may be reflecting a reactance response, which seems to wane as time goes by. Indeed, social support for functional dependence at T2 slightly predicted, as expected, more avoidance and less overdoing at T3. Moreover, and in line with the predictions of the Fear Avoidance Model of Pain (Vlayen & Linton, 2012), older adults' lower physical functioning and higher pain interference at baseline slightly predicted a lower activity engagement 6 weeks later, namely, by decreasing overdoing and increasing avoidance (physical functioning only). When looking at long-term indirect effects, poorer pain outcomes at baseline (higher pain severity, interference, and lower physical functioning) also slightly predicted more avoidance and less overdoing 3 months later, by increasing staff's social support for functional dependence. Although previous prospective studies have shown that activity patterns may shape chronic pain outcomes over time (Andrews et al., 2012), our findings highlight (small) pain outcome-driven direct and indirect effects (via social support for functional dependence) over activity patterns. The advanced age and long pain duration of most participants may partially explain this pattern of results. Noteworthy, these effects are very small, especially those related to avoidance. This may be partially explained by the very large auto-regressive effects of avoidance and overdoing, suggesting that these are very stable behavioral patterns among older adults (most) experiencing pain for many years.

In sum, although our hypothesis regarding the mediating role of activity patterns were not supported, findings show that poorer pain outcomes at baseline directly predicted older adults' lower activity engagement after 6 weeks and, by increasing staff's support for functional dependence, after 3 months. Our findings are among the first showing how interpersonal interactions may (to some extent) shape certain pain-related activity patterns, both through direct effects and by fueling the effects over time of pain outcomes on such activity patterns.

Limitations, Directions for Future Research, and Implications.

This study has some limitations that can inform future avenues for research. First, it only included relatively functional community-dwelling older adults. So, the extent to which similar findings would be found among more disabled older adults living in formal care institutions or even among young and middle-aged adults relying mostly on informal social support networks (e.g., family) needs to be further investigated. Second, data was collected in seven institutions that might vary in their characteristics (e.g., provider/user ratio) and formal care practices. Although preliminary analysis showed no significant institution effects on the study variables (Matos et al., 2017a), future research could consider the nested nature of the data of individuals within institutions. Third, although co-habitation status had no effect on the study variables, we did not assess individuals' informal support networks and relationships. As informal social support may influence older adults' needs and experiences of formal social support, future studies could investigate the synergies between both sources of social support in shaping chronic pain adaptation processes. Fourth, participants were mostly Portuguese, white women, with low levels of education. Whether culture, sex/gender, race/ethnicity, and socioeconomic status could modulate our findings is yet to be ascertained. Fifth, relevant chronic pain outcomes beyond pain disability and function, such as wellbeing, quality of life or psychological distress were not considered. As distress cues may influence received social support, future studies could include measures of anxiety and depression. Sixth, the POAM-P does not differentiate activity patterns' underlying motives (Kindermans et al., 2011; Nielson et al., 2014). For example, pacing could be done to reduce pain, increase activity levels or conserve energy for valued activities, which may bear different implications for chronic pain adjustment (Nielson et al., 2014). The fact that our findings did not show any association between pacing and any other study variables may in part be due to the POAM-P subscale not differentiating potentially conflicting pacing underlying motives. Therefore, measures allowing a more refined analysis of activity patterns (e.g., the Activity Patterns Scale by Esteve et al., 2016) should be used in future studies. Seventh , as this study had a relatively short observational time span (3 months) and mostly included older adults living with persistent pain for many years, it provides a narrow and time-limited view of the complex and cyclical relationships under study. Future studies could investigate whether a similar pattern of findings could be found since chronic pain onset and throughout its development trajectories. Finally, our study provides a one-sided view of complex interpersonal processes, by exclusively focusing on the perspective of the targets of support. Dyadic studies can provide a more complete picture of such processes, by encompassing the formal carers' perspectives (e.g., autonomous/volitional vs. controlled/pressured motivation to help), which can also influence the effectiveness of supportive interactions (Kindt et al., 2019). Furthermore, observational studies using standard behavioral coding procedures in natural settings could also inform the match between self-reported vs. actual/observed social support exchanges.

Despite its limitations, this study has important implications for health psychology research and practice. First, it stresses the role of interpersonal relationships in illness self-management and adaptation processes. More specifically, it shows how individual and interpersonal factors, by mutually influencing each other over time, shape chronic illness/pain adjustment. Second, by pointing out the cyclical temporal relationship between received social support, behavioral coping or self-management and health outcomes, this study emphasizes the need for future integration of psychosocial theoretical models to account for the complex chronic illness/pain adaptation processes over time and across chronic illness/pain trajectories. The explicit integration of time in future theoretical models on chronic illness/pain adaptation may promote the integration of existing (and apparently inconsistent) theoretical predictions and findings. Third, provides a better understanding of pain-specific received social support pitfalls, which is vital to inform the development of self-management interventions that harness the power of others. Fourth, to the best of our knowledge, our findings are among the first stressing the social roots and consequences of pain-related activity patterns. The extent to which other types of pain-related supportive interactions can shape activity patterns may be an important avenue for future research. Indeed, our previous studies have shown that formal social support for functional autonomy buffers the negative impact of pain intensity on older adults' pain disability by increasing their pain-related self-efficacy (Matos et al., 2017b). Whether this buffering effect may also be accounted for by activity patterns is yet unknown. As activity patterns are often the focus of chronic pain rehabilitation programs, this line of research may potentially contribute to the development of novel self-management interventions that resort to interpersonal relationships to increase the effectiveness of activity pacing interventions over time. Fifth, this study clarifies the role formal caregivers (e.g., staff at daycare centers) may play on older adults' chronic pain adjustment, which may inform the development of caregiver training interventions.

In conclusion, although further research on the temporal relationships between the received social support, activity patterns and chronic pain outcomes across chronic pain trajectories is called for, this study stresses the untapped potential of interpersonal relationships for increasing the effectiveness of future chronic pain self-management interventions.

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Table 1 – Means, standard deviations and Pearson correlations between the study variables at each time measurement point (T1, T2 and T3).

		M (SD)	PI T1	PI T2	PI T3	PF T1	PF T2	PF T3	PS T1	PS T2	PS T3	PPD T1	PPD T2	PPD T3	AV T1	AV T2	AV T3	PAC T1	PAC T2	PAC T3	OVD T1	OVD T2	OVD T3
Chronic Pain Outcomes	PI T1	3.62 (3.20)	-																				
	PI T2	3.75 (3.20)	.728**	-																			
	PI T3	3.81 (3.20)	.511**	.685**	-																		
	PF T1	1.72 (.69)	-.555**	-.495**	-.528**	-																	
	PF T2	1.67 (.68)	-.491**	-.603**	-.602**	.762**	-																
	PF T3	1.64 (.65)	-.446**	-.547**	-.618**	.826**	.813**	-															
	PS T1	3.04 (1.95)	.716**	.578**	.292**	-.415**	-.409**	-.268**	-														
	PS T2	3.26 (2.30)	.512**	.737**	.406**	-.317**	-.462**	-.343**	.582**	-													
	PS T3	3.39 (2.50)	.390**	.507**	.714**	-.339**	-.477**	-.375**	.361**	.546**	-												
Received Social Support	PPD T1	1.85 (.93)	.334**	.317**	.227**	-.231**	-.288**	-.255**	.326**	.224*	.204*	-											
	PPD T2	2.00 (.96)	.452**	.503**	.372**	-.306**	-.405**	-.389**	.345**	.387**	.347**	.697**	-										
	PPD T3	2.03 (.98)	.391**	.465**	.488**	-.382**	-.495**	-.455**	.215*	.351**	.476**	.610**	.666**	-									
Activity Patterns	AV T1	21.95 (14.43)	.474**	.412**	.349**	-.386**	-.345**	-.372**	.278**	.290**	.294**	.239**	.277**	.329**	-								
	AV T2	22.01 (14.50)	.460**	.444**	.365**	-.422**	-.362**	-.421**	.263**	.347**	.277**	.155	.216*	.267**	.900**	-							
	AV T3	21.62 (13.90)	.495**	.494**	.411**	-.430**	-.387**	-.442**	.278**	.372**	.364**	.220**	.316**	.371**	.886**	.883**	-						
	PAC T1	20.28 (11.05)	-.105	-.068	-.044	.133	.086	.060	-.012	.096	.117	-.036	.056	-.017	.031	-.019	.033	-					
	PAC T2	20.52 (11.22)	-.124	-.128	-.077	.113	.118	.093	.055	.036	.077	-.042	-.029	-.045	-.020	-.028	-.016	.876**	-				
	PAC T3	19.78 (10.71)	-.056	-.114	-.101	.109	.116	.087	.061	.055	.082	-.048	-.028	-.097	.071	.010	.029	.838**	.864**	-			
	OVD T1	14.58 (10.63)	-.403**	-.344**	-.351**	.388**	.309**	.363**	-.153	-.205*	-.211*	-.173*	-.225*	-.258**	-.773**	-.678**	-.637**	.023	.016	-.009	-		
	OVD T2	14.56 (10.22)	-.406**	-.389**	-.373**	.450**	.403**	.465**	-.154	-.247**	-.208*	-.094	-.214*	-.240**	-.692**	-.757**	-.643**	.037	.081	.058	.874**	-	

OVD T3	14.85 (10.39)	-.401**	-.408**	-.444**	.429**	.395**	.485**	-.121	-.239**	-.318**	-.195*	-.301**	-.369**	-.703**	-.672**	-.776**	.005	.058	.034	.792**	.804**	-

Note. ** p < .01; * p < .05; PI= Pain Interference; PF= Physical Functioning; PS= Pain Severity; PPD= Perceived Promotion of Dependence; AV= Avoidance; PAC= Pacing; OVD= Overdoing.

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Table 2 - Fit indices and indirect effects of the cross-lagged models with perceived promotion of dependence, activity patterns and pain severity.

Fit indices	χ^2/df	df	*p*	CFI	GFI	RMSEA (90%CI)	AIC
Avoidance							
Autoregressive model	3.70	21	<.001	.93	.88	.15 (.112, .181)	125.74
Cross-lagged model	5.17	9	<.001	.95	.93	.18 (.131 .233)	118.56
Parsimonious model	2.14	17	.004	.98	.94	.09 (.051, .137)	92.31
Overdoing (control. sex)							
Autoregressive model	2.34	25	<.001	.95	.92	.10(.069, .137)	118.65
Cross-lagged model	2.82	14	<.001	.96	.95	.12 (.076, .164)	121.50
Parsimonious model	2.13	17	.001	.93	.96	.09 (.057, .131)	113.02

Indirect effects	*ß*	SE	90% CI	*p*
Avoidance				
PPD T1 -> PPD T2 -> Avoidance T3	.06	.03	.022, .119	.009
PPD T1 -> PPD T2 -> PPD T3	.43	.08	.291, .534	.032
PS T1 -> PPD T2 -> Avoidance T3	.01	.01	.003, .041	.010
PS T1 -> PPD T2 -> PPD T3	.09	.04	.029, .176	.014
Avoid. T1 -> Avoid. T2 -> Avoid. T3	.86	.05	.725, .910	.026
Overdoing (control. Sex)				
PPD T1 -> PPD T2 -> Overdoing T3	-.08	.04	-.145, -.016	.043
PPD T1 -> PPD T2 -> PPD T3	.43	.08	.308, .549	.023
PS T1 -> PPD T2 -> Overdoing T3	-.02	.01	-.044, -.003	.014
PS T1 -> PPD T2 -> PS T3	.02	.06	.006, .066	.013
PS T1 -> PS T2 -> PS T3	.26	.06	.174, .358	.013
PS T1 -> PPD T2 -> PPD T3	.08	.04	.020, .160	.010
Overdoing T1 -> Overdoing T2 -> Overdoing T3	.76	.06	.634, .849	.013

Note. Parsimonious model = model without the non-significant paths. df = degrees of freedom; CFI = comparative fit index; GFI = goodness of fit index; RMSEA = root mean square error of approximation; AIC = Akaike information criterion. PS = pain severity; PPD= perceived promotion of dependence.

Table 3 - Fit indices and indirect effects of cross-lagged models with perceived promotion of dependence, activity patterns and pain interference.

Fit indices	χ^2/df	df	*p*	CFI	GFI	RMSEA (90%CI)	AIC
Avoidance							
Autoregressive model	4.05	21	<.001	.93	.88	.15 (.121, .189)	133.13
Cross-lagged model	4.52	9	<.001	.96	.94	.17 (.116, .218)	112.71
Parsimonious model	1.53	16	.080	.99	.96	.06 (.000, .112)	82.46
Overdoing (control. Sex)							
Autoregressive model	3.17	27	<.001	.93	.89	.13 (.009, .161)	141.47
Cross-lagged model	3.10	15	<.001	.96	.94	.13 (.087, .170)	126.53
Parsimonious model	2.44	22	<.001	.96	.93	.11(.070, .142)	119.69
Indirect effects				*ß*	SE	90% CI	*p*
Avoidance							
PI T1 -> PPD T2 -> Avoidance T3				.03	.02	.008, .071	.009
PI T1 -> PPD T2 -> PPD T3				.14	.04	.073, .197	.010
PI T1 -> PI T2 -> PPD T3				.12	.05	.045, .230	.011
Overdoing (control. Sex)							
PI T1 -> PPD T2 -> Overdoing T3				-.11	.04	-.167, -.045	.018
PI T1 -> PPD T2 -> PPD T3				.14	.04	.079, .198	.008
PI T1 -> PI T2 -> PPD T3				.27	.09	.131, .423	.014
Overdoing T1 -> Overdoing T2 -> Overdoing T3				.65	.06	.550, .749	.014

Note. Parsimonious model = model without the non-significant paths. df = degrees of freedom; CFI = comparative fit index; GFI = goodness of fit index; RMSEA = root mean square error of approximation; AIC = Akaike information criterion. PI = pain interference; PPD= perceived promotion of dependence.

Table 4

Fit indices and indirect effects of the cross-lagged models with perceived promotion of dependence, activity patterns and physical functioning.

Fit indices	χ^2/df	df	*p*	CFI	GFI	RMSEA (90%CI)	AIC
Avoidance							
Autoregressive model	4.24	21	<.001	.91	.88	.16 (.126, .194)	137.13
Cross-lagged model	4.29	9	<.001	.96	.94	.16 (.110, .214)	110.57
Parsimonious model	1.51	15	.091	.99	.97	.06 (.000, .113)	82.71
Overdoing (controlling sex)							
Autoregressive model	3.31	27	<.001	.91	.88	.13 (.104, .166)	145.30
Cross-lagged model	2.76	15	<.001	.96	.94	.12 (.076, .161)	121.41
Parsimonious model	2.09	22	.002	.97	.94	.09 (.054, .130)	111.89

Indirect effects	*ß*	SE	90% CI	*p*
Avoidance				
PF T1 -> PPD T2 -> Avoidance	-.11	.05	-.207, -.048	.005
PF T1 -> PPD T2 -> PPD T3	.28	.05	-.402, -.219	.002
Overdoing (controlling sex)				
PF T1 -> PPD T2 -> Overdoing T3	.02	.01	.009, .059	.007
PF T1 -> Overdoing T2 -> Overdoing T3	.11	.05	.043, .196	.008
PF T1-> PPDT2 -> PPDT3	-.08	.04	-.143, -.023	.010
PF T1 -> PF T2 - > PPD T3	-.19	.05	-.280, -.127	.003
PPD T1 -> PPDT2 -> PPDT3	.40	.08	.270, .510	.030
PPD T1 -> PF T2 - > PPD T3	.06	.03	.014, .108	.014
Overdoing T1 -> Overdoing T2 -> Overdoing T3	.64	.07	.528, .742	.009

Note. Parsimonious model = model without the non-significant paths. df = degrees of freedom; CFI = comparative fit index; GFI = goodness of fit index; RMSEA = root mean square error of approximation; AIC = Akaike information criterion. PF = physical functioning; PPD= perceived promotion of dependence.

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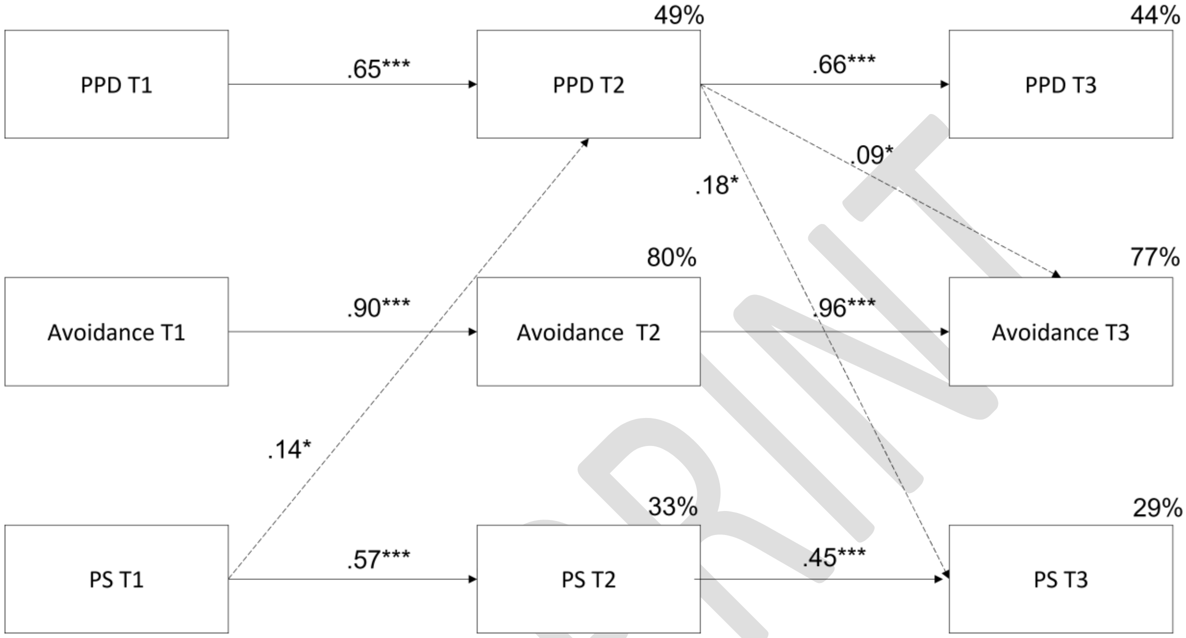
Supplementary Files

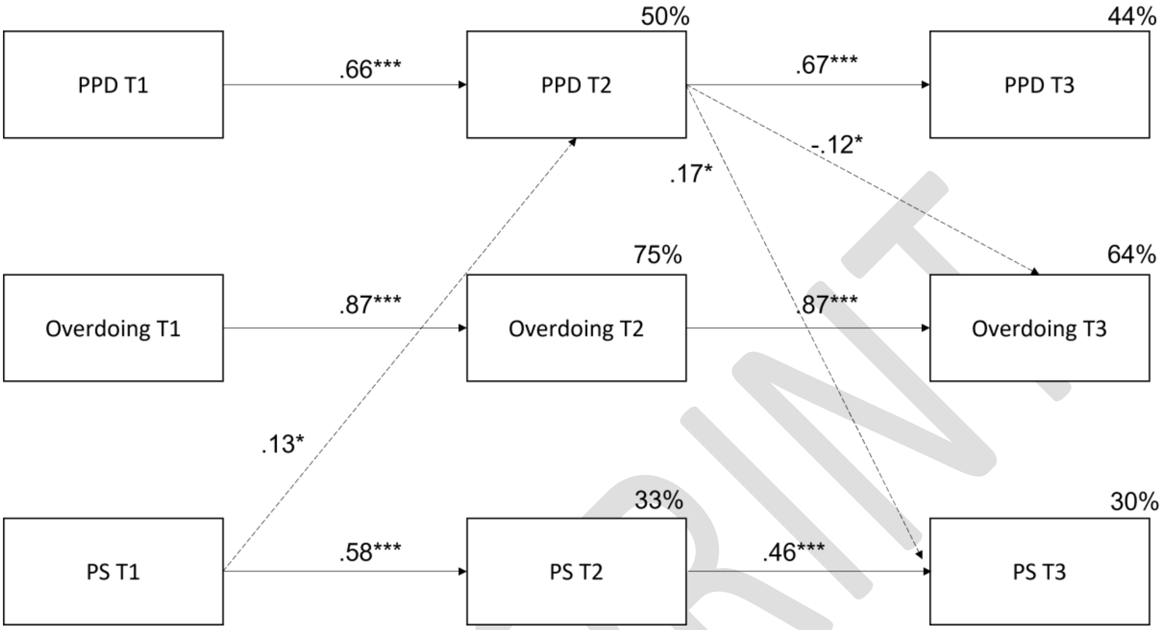
Figure S1
Parsimonious cross-lagged mediation model for Perceived Promotion of Dependence, Avoidance, and Pain Severity.



Note: *p<.05; **p<.01; ***p<.001; solid lines = autoregressive effects; dashed lines = crossover effects; standardized values are reported; % = R^2; PPD - Perceived Promotion of Dependence; PS = Pain Severity.

Figure S2

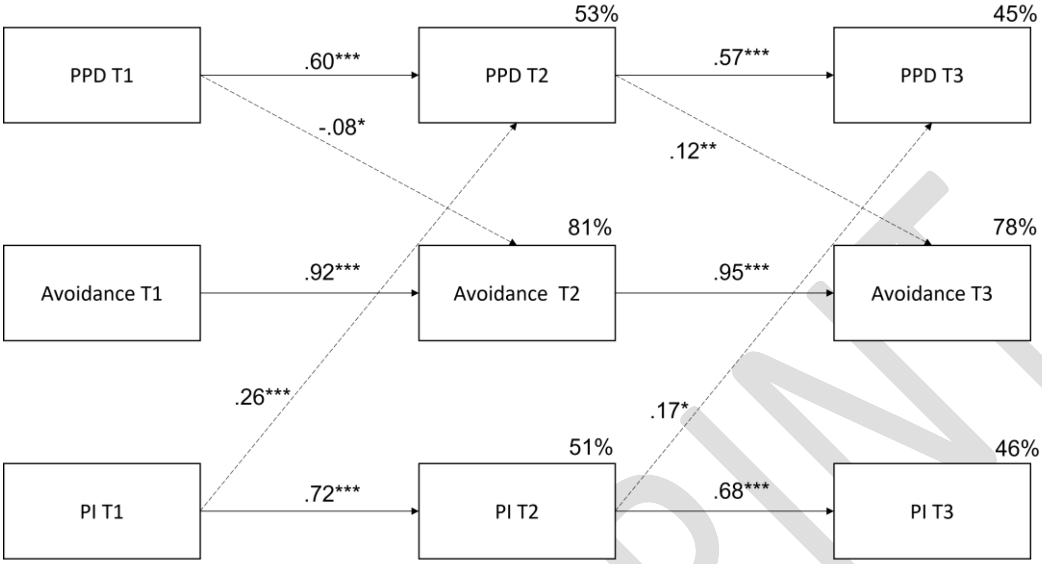
Parsimonious cross-lagged mediation model for Perceived Promotion of Dependence, Overdoing, and Pain Severity, controlling for participants' sex.



Note: *p<.05; **p<.01; ***p<.001; solid lines = autoregressive effects; dashed lines = crossover effects; standardized values are reported; % = R^2; PPD - Perceived Promotion of Dependence; PS = Pain Severity.

Figure S3

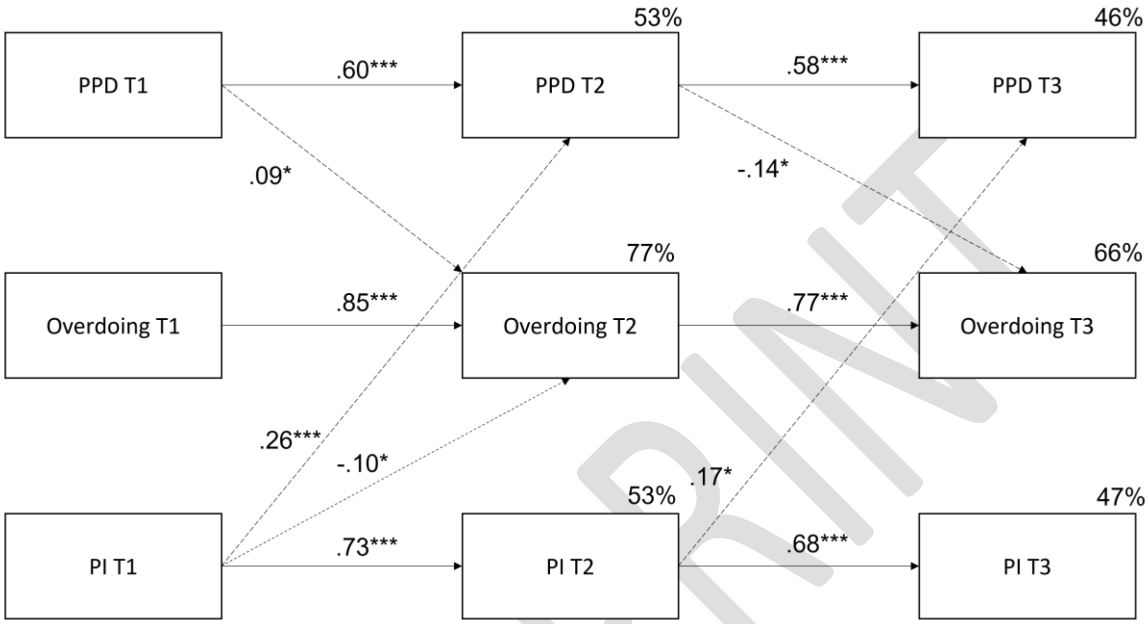
Parsimonious cross-lagged mediation model for Perceived Promotion of Dependence, Avoidance, and Pain Interference.



Note: *p<.05; **p<.01; ***p<.001; solid lines = autoregressive effects; dashed lines = crossover effects; standardized values are reported; % = R^2; PPD - Perceived Promotion of Dependence; PI = Pain Interference.

Figure S4

Parsimonious cross-lagged mediation model for Perceived Promotion of Dependence, Overdoing, and Pain Interference, controlling for participants' sex.



Note. *p<.05; **p<.01; ***p<.001; solid lines = autoregressive effects; dashed lines = crossover effects; standardized values are reported; % = R^2; PPD - Perceived Promotion of Dependence; PI = Pain Interference.

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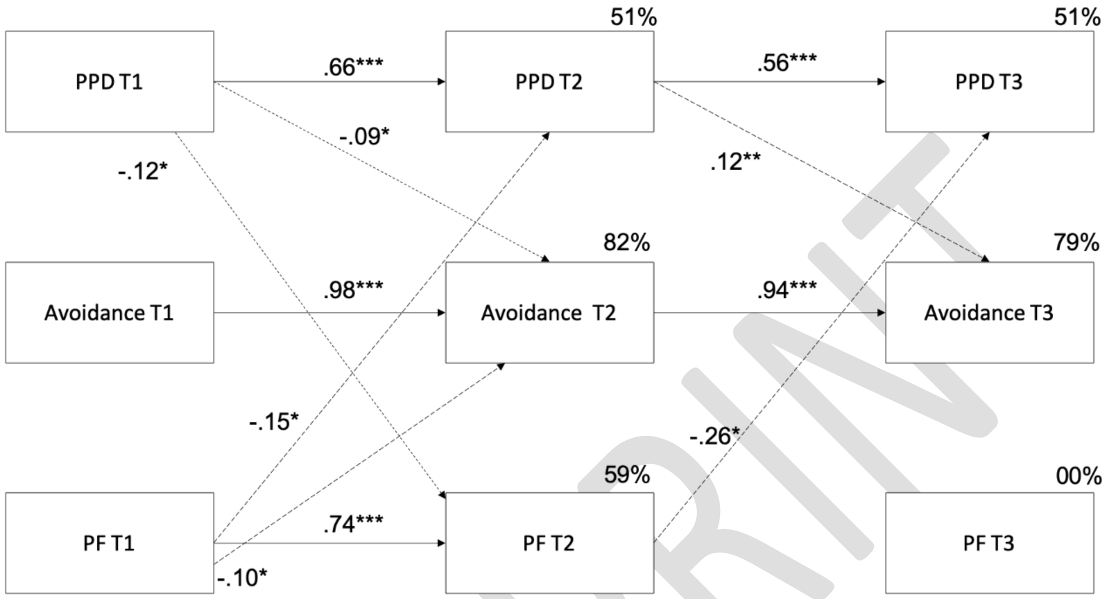
Figure S5

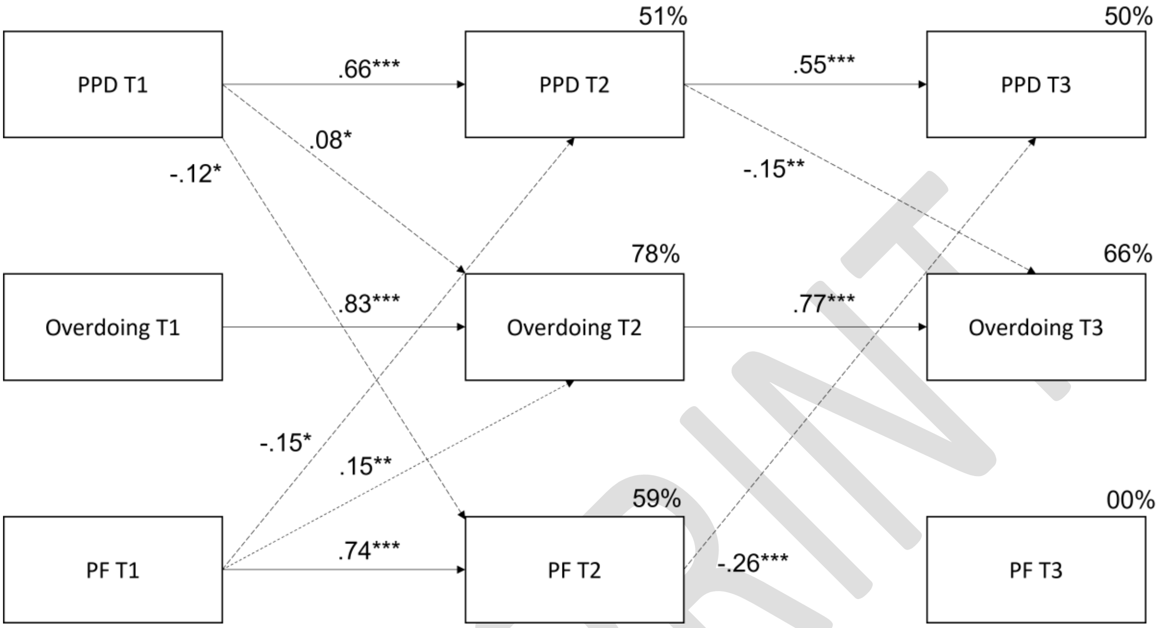
Parsimonious cross-lagged mediation model for Perceived Promotion of Dependence, Avoidance, and Physical Functioning.



Note: *p<.05; **p<.01; ***p<.001; solid lines = autoregressive effects; dashed lines = crossover effects; standardized values are reported; % = R^2; PPD - Perceived Promotion of Dependence; PF = Physical Functioning.

Figure S6

Parsimonious cross-lagged mediation model for Perceived Promotion of Dependence, Overdoing, and Physical Functioning, controlling for participants' sex.



Note: *p<.05; **p<.01; ***p<.001; solid lines = autoregressive effects; dashed lines = crossover effects; standardized values are reported; % = R^2; PPD - Perceived Promotion of Dependence; PF = Physical Functioning.