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Psychological Processes of ACL-Patients' Post-Surgery Rehabilitation:  
A Prospective Test of an Integrated Theoretical Model

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### Abstract

**Objectives:** The aim of this prospective study was to examine the utility of an integrated model comprising constructs from self-determination theory (SDT) and the theory of planned behavior (TPB) in predicting adherence to a post-surgery rehabilitation program in patients receiving anterior cruciate ligament (ACL) reconstruction. Constructs of the integrated model measured at baseline were expected to predict patients' rehabilitation adherence two months later.

**Method:** Patients ( $N = 121$ ,  $M$  age = 27.62, range = 18-53; 36.66% female) scheduled to have ACL reconstruction surgery within two months were recruited from a Hong Kong public hospital. At baseline and two-month follow-up, patients completed measures of perceived autonomy support from doctors and physiotherapists and treatment motivation from SDT, social cognition constructs from the TPB factors, and adherence to the post-surgery rehabilitation program recommended by their surgeon.

**Results:** Path analysis displayed good goodness-of-fit of the proposed model with the data ( $\chi^2 = 11.47$  (df = 9), CFI = .98, TLI = .93, RMSEA = .06 [90% CI = .00; .10]) after controlling for age, gender, time of surgery, post-surgery rehabilitation, and injury severity. Consistent with hypotheses, perceived autonomy support from physiotherapist and autonomous treatment motivation directly and indirectly predicted the TPB constructs and treatment adherence. However, there was no association between perceived autonomy support from doctors and autonomous motivation.

**Conclusion:** The integrated model was effective in explaining the psychological processes that relate to medical adherence. Findings also highlight the importance of the autonomy support from physiotherapists and provide evidence for potential intervention targets.

*Keywords:* Self-determination theory; theory of planned behavior; treatment motivation; behavioral compliance; social cognitive variables; rehabilitation adherence; anterior cruciate ligament rupture.

## Introduction

Anterior cruciate ligament (ACL) rupture is one of the most common and severe sport injuries among athletes (Mendonza, Patel, & Bassett, 2007; Wiggins et al., 2016). The standard treatment for ACL reconstruction patients is to undergo the ACL reconstructive surgery, followed by rehabilitation lasting six to nine months (Mendonza et al., 2007). Due to the prolonged recovery process, low adherence to post-surgery rehabilitation programs among ACL reconstruction patients is frequently reported (Niven, Nevill, Sayers, & Cullen, 2012; Wright, Galtieri, & Fell, 2014), and may lead to higher risk of re-injury (Kaeding et al., 2015; Webster & Feller, 2016; Wiggins et al., 2016). Therefore, it is essential for ACL reconstruction patients to adhere their prescribed rehabilitation programs. In order to enhance patients' medical adherence, numerous studies have suggested the application of psychological and behavioral theories to identify the modifiable psychological determinants of rehabilitation adherence (Chan, Lee, Hagger, Mok, & Yung, 2017; Chan, Lonsdale, Ho, Yung, & Chan, 2009; Osterberg & Blaschke, 2005; Picha & Howell, 2018). In the current study, we applied an integrated theoretical model (Hagger & Chatzisarantis, 2009; Hagger, Chatzisarantis, & Biddle, 2002) comprising constructs from self-determination theory (SDT; Deci & Ryan, 1985) and the theory of planned behavior (TPB; Ajzen, 1991) to identify the psychological determinants of ACL reconstruction patients' adherence to rehabilitation. The current research is expected to provide important formative data to identify potential modifiable targets for interventions aimed at promoting rehabilitation adherence.

In the integrated model, concepts and psychological factors from SDT and TPB are integrated to identify the motivational and belief-based determinants of behavior, and the process by which those determinants relate to behavior. After its initial application in the context of

physical activity (Hagger et al., 2002), the model has widely been applied to different health contexts such as dieting (Jacobs, Hagger, Streukens, De Bourdeaudhuij, & Claes, 2011), disease prevention (Chan, Fung, Xing, & Hagger, 2014; Chan, Yang, Mullan, et al., 2015), rehabilitation (Chan & Hagger, 2012a), and sport injury prevention (Chan & Hagger, 2012b). A central premise of the model is the distinction between autonomous and controlled forms of motivation from SDT (Deci & Ryan, 1985). Individuals experience their behavior as autonomously motivated when they perform the behavior for intrinsic (e.g., acting for fun, interest, and self-satisfying reason), integrated (e.g., acting for behavior that is synthesis with self), or identified (e.g., acting for achieving personally valued goal) reasons. In contrast, individuals experience their actions as controlled when they perform actions for introjected (e.g., acting to satisfy pride or ego-oriented outcomes, or to avoid shame and guilt) or external (e.g., acting for compliance, or to avoid punishment) reasons. Individuals experiencing actions as autonomously motivated are more likely persist, and have better performance, than those experiencing their actions as controlled motivated (Deci & Ryan, 2000; Hagger & Chatzisarantis, 2009). This is because autonomous motivation is consistent with three basic psychological needs: autonomy (the need of making their own decisions), competence (the needs for being an effective agents) and relatedness (the need of being connected with others), which are essential psychological *nutriments* for optimal functioning (Deci & Ryan, 2000). When these needs are fulfilled in an autonomy-supportive environment, individuals are more likely to endorse more autonomous motivation, leading to better adherence and behavioral outcomes (Deci & Ryan, 2000; Edmunds, Ntoumanis, & Duda, 2007; Ryan, 1995; Silva et al., 2008).

A key proposition of the integrated model is that the link between forms of motivation from SDT and a given target behavior is not direct, but is instead mediated by the social

cognition constructs from the TPB (Ajzen, 1991): attitude (i.e., instrumental and affective evaluations of the behavior), subjective norms (i.e., beliefs that significant others approve and undertake the behavior), and perceived behavioral control (PBC; perceived capacity and controllability of the behavior). According to the theory, intention (i.e., the extent to which one plans to perform the action) is the most proximal predictor of the target behavior, and mediates the effects of attitude, subjective norm, and PBC on behavior. Importantly, consistent with Deci and Ryan predictions, the integrated model proposes that effects of the motivational predictors from SDT on behavior are mediated by the social cognition constructs and intentions.

The integrated model is considered to provide a more comprehensive explanation of the psychological processes by which motivational constructs from SDT relate to behavior (Chatzisarantis, Hagger, & Smith, 2007). Both theories provide complimentary explanations of the motivational processes that precede action. For example, SDT identifies the motivational conditions within the individual and the social environmental factors associated with individuals' motivation and behaviors, but does not explicitly delineate the proximal decision making processes that lead to behavior (Gollwitzer & Sheeran, 2006; Hagger & Chatzisarantis, 2009). On the other hand, the TPB outlines proximal social cognitive determinants of behavior, but not the distal origins of determinants (Hagger et al., 2002).

Previous studies applying either SDT or TPB alone in the context ACL surgery rehabilitation have not fully explained the motivational processes that precede patients' treatment adherence. For instance, an initial SDT-based study found that ACL reconstruction surgery patients reported higher autonomous treatment motivation and treatment adherence when they perceived their physiotherapists as autonomy-supportive (Chan et al., 2009). The tenets of SDT were supported, but the findings did not reveal the process by which perceived need-supportive



style and forms of motivation were linked to intention and future engagement of behaviors given the cross-sectional design and retrospective measure of treatment adherence. Niven et al. (2012) conducted a prospective study based on the TPB to predict post-surgery rehabilitation adherence among ACL reconstruction patients. Their results indicated that intention was positively and significantly associated with rehabilitation adherence at weeks 4, 6, and 8 post-surgery. However, attitude, subjective norms, and PBC were not significant predictors of patients' rehabilitation intention and adherence. The non-significant prediction of TPB components in Niven et al. (2012) study are in stark contrast with findings from other studies that have applied the TPB to explain intention toward, and adherence to, rehabilitation programs (Chan & Hagger, 2012a). These inconclusive findings highlight the need for further research applying these theories and, in particular, integrating constructs from both SDT and the TPB in order to provide a more comprehensive explanation the factors and processes that relate to adherence to rehabilitation in ACL reconstruction patients.

In summary, previous studies using SDT and TPB have examined how the components of each theory are related to ACL reconstruction patients' intention and adherence to rehabilitation (Chan et al., 2009; Niven et al., 2012). However, these studies did not integrate the motivational constructs from SDT and the social cognitive factors from the TPB into a single psychological framework that could provide a more comprehensive explanation of determinants of rehabilitation adherence, and the processes involved (Hagger & Chatzisarantis, 2009). In addition, research has highlighted the importance of the physician-patient relationship for medical adherence (Delamater, 2006; Osterberg & Blaschke, 2005), but previous studies of SDT or TPB have not taken perceived autonomy support provided by doctors into account in the prediction of patients' rehabilitation adherence. The abovementioned research highlights

important research gaps, which we aim to address by conducting a prospective study using the integrated model of SDT and TPB as the framework.

Using a prospective study design, the present study aimed to investigate the psychological determinants of ACL reconstruction patients' adherence to rehabilitation using an integrated model comprising constructs from SDT and the TPB. Based on the tenets of the integrated model and the findings of previous studies (Chan & Hagger, 2012a; Chatzisarantis et al., 2007; Hagger & Chatzisarantis, 2009), we proposed the following hypotheses: Perceived autonomy support from physiotherapists and doctors would be positively related to autonomous motivation, but not controlled motivation, with respect to their participation in their rehabilitation programs (H1); Attitude, subjective norm, and PBC would be positively associated with autonomous motivation, but not with controlled motivation, toward rehabilitation participation (H2); Attitude, subjective norm, and PBC would be positively related to rehabilitation intention (H3); and intention would positively related to prospectively-measured rehabilitation adherence (see Figure 1).

<INSERT FIGURE 1 ABOUT HERE>

## **Method**

### **Participants and Procedures**

Ethical approval for the current study was obtained from the University of Hong Kong research ethics committee (approval #UW 16-1023). ACL surgery patients were recruited from the orthopedic and traumatology clinics of a local public hospital in Hong Kong. Patients were attending their first medical consultation with their orthopedic surgeon after their ACL reconstruction surgery, which typically occurred two months post-operatively. Patients were

initially screened against the following inclusion criteria: (1) age range between 18 and 60; (2) had receive ACL reconstruction surgery performed in the previous two months; and (3) were regular smartphone users. One hundred and twenty-one patients ( $M_{\text{age}} = 27.81$ ,  $SD = 8.50$ , range = 18 to 53; Male = 63.64%) signed informed consent forms and agreed to take part in the study. Participants' ACL rupture occurred an average 8.86 ( $SD = 14.45$ ) months previously, and underwent their reconstruction surgery an average of 2.77 ( $SD = 1.58$ ) weeks previously. Approximately half of the participants (51.33%) reported meniscus injury in addition to their ACL rupture. Participants completed a survey package comprising measures of the constructs of the integrated model (e.g., perceived autonomy support, motivation, social cognitive variables, treatment adherence) and salient demographic variables (e.g., knee function) at the time of recruitment (baseline) and two months after the baseline.

## Measurement

**Autonomy support and treatment motivation from SDT.** The Health Care Climate Questionnaire (HCCQ) is a single-dimension scale that has been widely used to measure perceived autonomy support from medical professionals (Williams, Grow, Freedman, Ryan, & Deci, 1996). We adopted the six-item Chinese-language version of the HCCQ to measure patients' perceived autonomy support from doctors and physiotherapists (Chan, Hagger, & Spray, 2011; Chan et al., 2009). Treatment motivation was measured using the autonomous (five items) and controlled motivation (eight items) dimensions of the Treatment Self-Regulation Questionnaire (TSRQ; Levesque et al., 2006). We used the Chinese-language version of alTSRQ that was developed for measuring rehabilitation motivation in orthopedic patients (Chan et al., 2009). Participants responded to items of the HCCQ and TSRQ using a seven-point Likert scale (0 = *not at all true*; 7 = *very true*).

**Social cognition variables from TPB.** Measures of participants' attitude (six items), subjective norms (three items), PBC (five items) and intention (three items) toward their compliance with the rehabilitation program were developed for the injury rehabilitation context (Ajzen, 2002; Orbell, Hagger, Brown, & Tidy, 2006). The first three variables referred to their beliefs at the time of assessment and intention represented the extent to which the patient planned to follow their rehabilitation program over the next month. Participants rated items on a scale on seven-point scales (1 = *strongly disagree*; 7 = *strongly agree*). These items have demonstrated good internal consistency and validity in research on ACL rehabilitation in Chinese context (Chan & Hagger, 2012a).

**Treatment adherence.** We used self-reported injury rehabilitation adherence scale to capture participants' frequency (one item) and effort (one item) in completing rehabilitation with 1 (never/minimum effort) to 7 (often/maximum effort) as anchors (Kolt, Brewer, Pizzari, Schoo, & Garrett, 2007). We adopted the Chinese version of the scale that was developed for measuring the rehabilitation adherence among ACL reconstruction patients (Chan et al., 2009).

**Knee condition.** Finally, patients' knee function was measured using the International Knee Documentation Committee subjective knee evaluation form. The form is one of the most widely used self-report instruments to assess knee function (Hefti, Müller, Jakob, & Stäubli, 1993). The form measures symptoms, functionality when performing sports and daily activities, and overall knee function on 18 items. The scale produces a total knee function score ranging from 0 to 100. A higher scoring refers to an absence of symptoms and no limitations to daily or sporting activities. The subjective knee evaluation score would be used to as a control variable in our final analyses.

## Data Analysis

The psychological variables scores were calculated by taking the mean of their corresponding items. Proposed relations among the integrated model were tested using path analysis using Mplus version 7.2 (Muthén & Muthén, 2015). The analysis enabled evaluation of the overall adequacy of the fit of the model with the data, and standardized parameter estimates provided effect size and statistical significance values for each model path. All the paths were adjusted for the effects of age, sex, months of post-ACL-rupture, weeks of post-surgery, meniscus injury, and subjective knee evaluation. Conventional fit indices were used to assess the model fit (Hu & Bentler, 1999): the comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR). Values exceeding .90 for the CFI, and TLI, and below 0.08 for the RMSEA and SRMR, were considered indicative of acceptable model fit. Analysis scripts and scales are available online at <https://osf.io/38njh/>.

With respect to treatment of missing data, 29 out of 121 (23.97%) participants did not complete the 2-month follow-up survey due to relocation, withdrawal of consent, and loss to follow-up. Missing values analysis using Little's test supported the hypothesis that data were missing completely at random,  $\chi^2 = 27.32$ ,  $df = 23$ ,  $p > .05$  (Little & Rubin, 2019). We adopted the maximum likelihood estimation method for the path analysis, which adjusts the likelihood function so that each case contributes information on the observed variables. Studies have supported the application of maximum likelihood estimation in adequately accounting for missing data patterns (Larsen, 2011; Shin, Davison, & Long, 2017).

## Results

Descriptive statistics for all measured variables results are presented in Table 1. Cronbach alpha internal consistency coefficients for the psychological variables were satisfactory (range = .80 to .98). The path model suggested acceptable fit of the model with the data,  $\chi^2 = 27.62$  (df = 21), CFI = .98, TLI = .93, RMSEA = .06 [90% CI = .00 to .11], and SRMR = .04.

Focusing on the model paths, consistent with our hypothesis (H1), perceived autonomy support from physiotherapists was positively and significantly related to autonomous motivation with a medium effect size ( $\beta = .42, p < .01$ ), but was not significantly related to controlled motivation ( $\beta = .02, p > .05$ ). As expected, perceived autonomy support from doctors was not significantly related to controlled motivation and the effect size was small ( $\beta = .15, p > .05$ ), but its relationship with autonomous motivation was also not significant and small in size ( $\beta = .12, p > .05$ ), which is in contrast to our hypothesis. In line with our hypothesis (H2), attitude ( $\beta = .23, p < .01$ ), subjective norms ( $\beta = .36, p < .01$ ), and PBC ( $\beta = .49, p < .01$ ) were positively and significantly related to autonomous motivation with small-to-medium effect sizes, but their associations with controlled motivation were not significant and the effect size was small ( $\beta = .07$  to  $.14, p > .05$ ). As expected (H3), attitude ( $\beta = .21, p < .01$ ), subjective norms ( $\beta = .25, p < .01$ ), and PBC ( $\beta = .31, p < .01$ ) were positively and significantly related to intention with small-to-medium effect sizes. Finally, rehabilitation adherence was positively and significantly related to intention with a medium effect size ( $\beta = .40, p < .01$ ), as predicted (H4).

<INSERT TABLE 1 ABOUT HERE>

## Discussion

The present study aimed to apply an integrated model comprising constructs from SDT and the TPB to identify the determinants of post-surgery rehabilitation among ACL reconstruction patients, and the processes involved (Hagger & Chatzisarantis, 2009; Hagger et al., 2002). Findings provide support for study hypotheses. The only exception was the hypothesized positive association between perceived autonomy support from doctors and autonomous motivation (H1), which was rejected. Overall, the pattern of results supported the utility of the integrated model in predicting ACL reconstruction patients' adherence to their post-surgery rehabilitation.

### **Perceived Autonomy Support from Doctors and Physiotherapists**

Perceived autonomy support from doctors has consistently been found to be related to patients' motivation and behavior toward treatment, consistent with our hypothesis (H1) (Koponen, Simonsen, & Suominen, 2017; Williams & Deci, 2001; Williams, McGregor, King, Nelson, & Glasgow, 2005). The current study extended this work by demonstrating that autonomy support from physiotherapists, rather than doctors, predicted autonomous motivation. These findings indeed support a key tenet of SDT regarding the adaptive role of perceived autonomy support (Chan & Hagger, 2012a; Hagger et al., 2009; Hagger, Sultan, Hardcastle, & Chatzisarantis, 2015) and the previous findings of Chan et al. (2009). Current evidence suggests that not all social agents are equally important when it comes to identifying the determinants of patients' treatment motivation (Chan, Keegan, et al., 2018; Chan, Lonsdale, & Fung, 2012). For instance, Chan et al. (2011) found that the autonomy support from physiotherapists, but not coaches, was an important predictor autonomous treatment motivation among elite athletes recovering from sport injury. Physiotherapists therefore seem to have a more important role than doctors in fostering patients' motivation and adherence towards rehabilitation. This might be

particularly true in the Hong Kong context because doctors in public hospitals only spend eight minutes on average with each outpatient consultation (Chan, 2017). This presents considerable challenges for doctors to utilize an autonomy supportive style and engage in sufficient interaction and rapport formation with the patients to foster autonomous motivation toward rehabilitation (Dugdale, Epstein, & Pantilat, 1999; Gross, Zyzanski, Borawski, Cebul, & Stange, 1998). Physiotherapists, on the other hand, have ample time with patients across multiple sessions, and, therefore, have the opportunity to engage in sufficient autonomy support for rehabilitation. Future studies should also account for multiple social agents (e.g., family, peers) as potential other sources of autonomy support for rehabilitation, which may be more salient and pervasive than doctors and physiotherapists.

### **Treatment Motivation and Social Cognitive Factors**

Consistent with our hypothesis (H2), autonomous motivation predicted attitude, subjective norms, and PBC, but controlled motivation did not. The results were congruent with the propositions of the integrated model and other rehabilitation studies applying the model (Chan & Hagger, 2012a; Chan et al., 2009; Hagger & Chatzisarantis, 2009; Russell & Bray, 2010). Findings suggest that patients were autonomously motivated when they understood the reasons for, and value of, following the rehabilitation regime. This was also reflected in a more favorable evaluation of their rehabilitation program (attitude), greater beliefs that significant others supported rehabilitation participation (subjective norms), and higher beliefs in their capability to complete their rehabilitation (PBC). Another noteworthy finding was that the effect of autonomous motivation on attitudes was weaker than its effect on subjective norms and PBC. These findings are in line with another rehabilitation studies (Chan & Hagger, 2012a). To speculate, patients might have low affective attitude toward the prolonged rehabilitation program



(Carson & Polman, 2010; Culvenor & Barton, 2018; Pizzari, McBurney, Taylor, & Feller, 2002). Although autonomously-motivated patients acknowledge the rationale and the importance of rehabilitation (positive instrumental attitude), they could still find the repetitive rehabilitation unpleasant and unenjoyable. Several studies have reported that ACL reconstruction patients consider their rehabilitation programs 'boring' and 'dull' (Carson & Polman, 2010; Culvenor & Barton, 2018; Pizzari et al., 2002). This may be a major reason why the observed size of the effect of autonomous motivation on attitude was lower than the effects observed for autonomous motivation on subjective norm and PBC. Similarly, controlled motivation did not predict the three social cognition constructs as hypothesized. Given the substantive effort required over an extended period, it is unlikely that participating in the rehabilitation program out of obligation alone is sufficient to lead to adherence to programs (Chan & Hagger, 2012a; Chan et al., 2009). Previous studies applying the integrated model found inconsistent results (Hagger & Chatzisarantis, 2016; Chan et al., 2012; Chan, Dimmock, et al., 2015; Hagger et al., 2018) regarding the relationship between controlled motivation and subjective norms. Some researchers have suggested that subjective norms should be associated with controlled motivation (Chatzisarantis & Biddle, 1998; Sheeran, Norman, & Orbell, 1999). The argument was that the subjective norms could be seen as peer pressure which is consistent with the external referenced reason in controlled motivation. On the other hand, individuals might perceive their significant others as autonomy supportive, and, therefore, be more likely to persist (Chan, Fung, Xing, & Hagger, 2014; Chan & Hagger, 2012a). Current results support the latter proposal and imply that autonomous motivation effectively predicted all three social cognition variables in ACL rehabilitation context, while controlled motivation did not.

### **Social Cognitive Factors and Intention**

Attitude, subjective norm, and PBC were positively and significantly related to intention, consistent with our hypothesis (H3), and the findings are consistent with the premises of the integrated model (Chan & Hagger, 2012a; Hagger & Chatzisarantis, 2009) and the TPB literature (Ajzen, 1991). PBC had the largest effect on intention relative to the effects of subjective norm and attitude. This finding has been observed by previous studies examining the social cognition determinants of rehabilitation (Blanchard, 2008; Hagger & Chatzisarantis, 2009; Sniehotta, Scholz, & Schwarzer, 2005). These findings could be due to the fact that study measures were taken in the early stage of patients recovery from their ACL surgery, and PBC could be a particularly salient determinant of rehabilitation at this stage because their functional ability could be limited and they could encounter difficulties following their daily rehabilitation regimen (Picha & Howell, 2018; Thomee et al., 2007). PBC is particularly relevant to engaging in behaviors when there are considerable obstacles to overcome (Bandura, 1986). This finding underlines the importance of PBC in the early phases of ACL post-surgery rehabilitation. Hence, practitioners should consider implementing behavior change strategies that can enhance ACL reconstruction patients' PBC (e.g., improving the accessibility of the rehabilitation protocols, encouraging observing others and modeling, promoting goal-setting and providing positive feedback) (Chan & Hagger, 2012b; Chan, Lee, Hagger, et al., 2017). However, current findings were contrary to those of Niven et al. (2012), who concluded that attitude, subjective norms, and PBC were not associated with intentions to engage in rehabilitation. We speculate that the participants' background may contribute to the different results. In Niven et al. (2012)'s sample comprised entirely of athletes whereas some of the participants in our study did not rupture their ACL during sport activities (e.g., some received their injury while at work). Participants in the current study and the athletes in Niven et al.'s study might, therefore, have very different sets of

motives and beliefs behind treatment because ACL rehabilitation is directly related to athletes' return-to-play, but it might not always be the highest priority for ordinary patients.

### **Intention and the Prediction of Treatment Adherence**

Patients' intention predicted follow-up rehabilitation adherence, consistent without hypothesis (H4). This finding is in line with the propositions of the TPB, and with previous research which found that intention predicted athletes' adherence to ACL rehabilitation post-reconstruction (Niven et al., 2012). Taken together, these results highlight the importance of intention in determining rehabilitation adherence on this context. Intention can be fostered by promoting the determinants of intentions, namely, attitudes, subjective norms, and PBC (see Sheeran et al., 2016). However, we should not overlook the fact that intention only explained 22% of the variance in treatment adherence, so there is a major proportion of the variance remained unexplained. Although the amount of variance explained in behavior in our study was comparable to that of previous studies and meta-analytic findings (Bélanger-Gravel, Godin, & Amireault, 2013; Rhodes & de Bruijn, 2013), bridging the gap between intention and behavior would be an important goal for future research applying TPB or the integrated model. To bridge the intention-behavior gap, researchers have proposed prompting the formation of action plans or implementation intentions as a means to bolster the intention-behavior relationship (Hagger et al., 2016; Sheeran & Webb, 2016). Such plans involved the formation of if-then plans, which facilitate intention enactment (Gollwitzer, 2014). Future research should consider examining the effect of action plans or implementation intentions in strengthening the link between intention and rehabilitation adherence among ACL-patients. It may also be worthwhile to consider behavior change strategies that could enhance individuals' self-regulation in the rehabilitation settings, such as the use of diaries to monitor cues to perform rehabilitation exercises (Hagger,

2018) or calendars to monitor daily rehabilitation progress (Schüz, Sniehotta, & Schwarzer, 2006).

### **Limitations and Future Directions**

There are several theoretical and methodological limitations of the present study that should be acknowledged. First, we did not control for the effects of other theoretically-relevant confounding factors that could have affected the study findings. For example, autonomy preferences, defined as individuals' desire for autonomy (Ende, Kazis, Ash, & Moskowitz, 1989), has been found to moderate the effect of perceived autonomy support on other psychological or behavioral outcomes (Lee & Lin, 2010; Resnicow et al., 2008). The non-significant association between perceived autonomy support from doctors and autonomous motivation in the present study could be due to the possibility that ACL reconstruction patients with lower autonomy preference prefer their doctors to decide their treatment options (Lee & Lin, 2010). Future studies should consider the potential moderating effect of patients' autonomy preference when investigating the relationship between autonomy support and treatment motivation.

Another possible theoretically relevant confounder is the background motivation of the patients. Previous studies adopting the trans-contextual model (Chan & Hagger, 2012a; Chan, Yang, Hamamura, et al., 2015; Hagger et al., 2009; Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003) have found that individuals' motivation in their environment (e.g., sport, or occupational setting) is related to the forms of motivation that determine injury rehabilitation (Chan & Hagger, 2012a, 2012c). Specifically, individuals who are autonomously motivated at work are more likely to endorse autonomous motivation for their rehabilitation from injuries that

occurred at work. Interventions promoting ACL reconstruction surgery patients' motivation toward rehabilitation should take their background motivation into account because it may indicate the extent to which they are predisposed to motivational styles in their rehabilitation.

In terms of methodological limitations, it is important to note that self-report measures may be subject to recall bias and social desirability (Chan et al., in press; Osterberg & Blaschke, 2005). Although self-report measurements of treatment adherence have shown adequate reliability (Chan et al., 2009; Niven et al., 2012; Pizzari, Taylor, McBurney, & Feller, 2005), future studies may adopt direct observation to provide more accurate and reliable assessments of behavior (Osterberg & Blaschke, 2005), despite the challenges (e.g., burden on participants) of applying this method (Brewer, 1998). We also propose that researchers should include objective measures of clinically-relevant outcomes in ACL rehabilitation, such as the knee laxity test (Daniel, Stone, Sachs, & Malcom, 1985), isokinetic knee muscle test (Wilk, Romaniello, Soscia, Arrigo, & Andrews, 1994), and the single leg hop test (Logerstedt et al., 2012). With respect to psychological measures, researchers should investigate whether implicit association tests could provide an alternative assessment of individuals' motivation and social cognition constructs with respect to rehabilitation behaviors (Chan, Lee, Tang, et al., 2017; Chan, Keatley, Tang, Dimmock, & Hagger, 2018). Such measures are less susceptible to bias and common method variance, and may reflect constructs that relate to automatic or habitual responses (Keatley, Chan, Caudwell, Chatzisarantis, & Hagger, 2015).

Furthermore, the prospective design of this study only permitted us to draw conclusions on the predictive validity of the integrated model on future behavior, but does not permit strong conclusions regarding causal relations between the psychological constructs and rehabilitation behavior. Future studies should adopt longitudinal (e.g., cross-lagged panel design) or

experimental (e.g., randomized controlled trial) designs that help establish the temporal and causal relations, respectively, among the model variables (Chan, Ivarsson, et al., 2015; Jacobs et al., 2011; Sheeran & Silverman, 2003). The literature has identified a number of behavior change strategies based on the integrated model. For instance, provision of autonomy support could facilitate change in patients' autonomous motivation and subsequent behavioral determinants (Chan & Hagger, 2012a; Chan, Lee, Hagger, et al., 2017). Autonomous motivation can be promoted by satisfying the three psychological needs, autonomy (e.g., providing different rehabilitation exercise for patients to choose, highlights the rationale of following the regime), competence (e.g., promoting self-comparison instead of comparing with others, providing encouragement) and relatedness (e.g., actively listening to patients' concerns) (Chatzisarantis & Hagger, 2009; Deci & Ryan, 2008; Teixeira et al., 2019; Tessier, Sarrazin, & Ntoumanis, 2010); Teixeira et al., 2019). In order to foster patients' intention toward rehabilitation, educational information and encouragement toward patients' attitude (e.g., promoting the pros and resolving the cons of ACL rehabilitation), subjective norms (e.g., organizing forums for patients to share their insights or progress of rehabilitation with other patients), and PBC (e.g. demonstrating rehabilitation exercises to patients) could also be provided (Johnston, Johnston, Pollard, Kinmonth, & Mant, 2004; Montano & Kasprzyk, 2015). Future studies should consider using randomized control trial based on the framework of integrated model of SDT and TPB (Hagger & Chatzisarantis, 2009), and may examine if targeting change in the psychological factors of the integrated model ultimately fosters better long-term behavioral adherence toward treatment.

### **Conclusion**

The present study is the first prospective test of the integrated model of SDT and TPB in explaining ACL reconstruction patients' adherence toward post-surgery rehabilitation.

Consistent with the key tenets of the model, findings revealed that autonomy support from physiotherapists, rather than their doctors, was directly and indirectly related to autonomous motivation, social cognitive factors, and adherence of post-surgery rehabilitation. Current findings pave the way for using the integrated model as the basis for interventions aimed at promoting patients' adherence toward post-surgery rehabilitation.

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Table 1. Descriptive Statistics and Correlations Among Variables ( $N=121$ )

Variables	1	2	3	4	5	6	7	8	9
1. Autonomy support – Physio (T1)	1								
2. Autonomy support – Doctor (T1)	.61**	1							
3. Autonomous motivation (T1)	.53**	.45**	1						
4. Controlled motivation (T1)	.16	.14	.29**	1					
5. Attitude (T1)	.48**	.39**	.49**	.26**	1				
6. Subjective norm (T1)	.44**	.47**	.57**	.23*	.71**	1			
7. PBC (T1)	.50**	.43**	.65**	.19*	.59**	.75**	1		
8. Intention (T1)	.50**	.51**	.64**	.16	.75**	.68**	.60	1	
9. Treatment Adherence (T2)	.44**	.37**	.53**	.12	.48**	.36**	.46**	.51**	1
Cronbach's alpha	.95	.96	.82	.81	.85	.80	.83	.98	.87
Mean	5.90	6.01	6.14	4.14	6.05	6.06	6.02	6.35	11.06
Standard Deviation	1.03	0.89	0.80	1.22	0.73	0.80	0.75	0.76	2.09

*Note.* Physio = Physiotherapist; PBC = Perceived Behavioral Control; T1 = Time 1; T2 = Time 2.

\*  $p < .05$  \*\*  $p < .01$

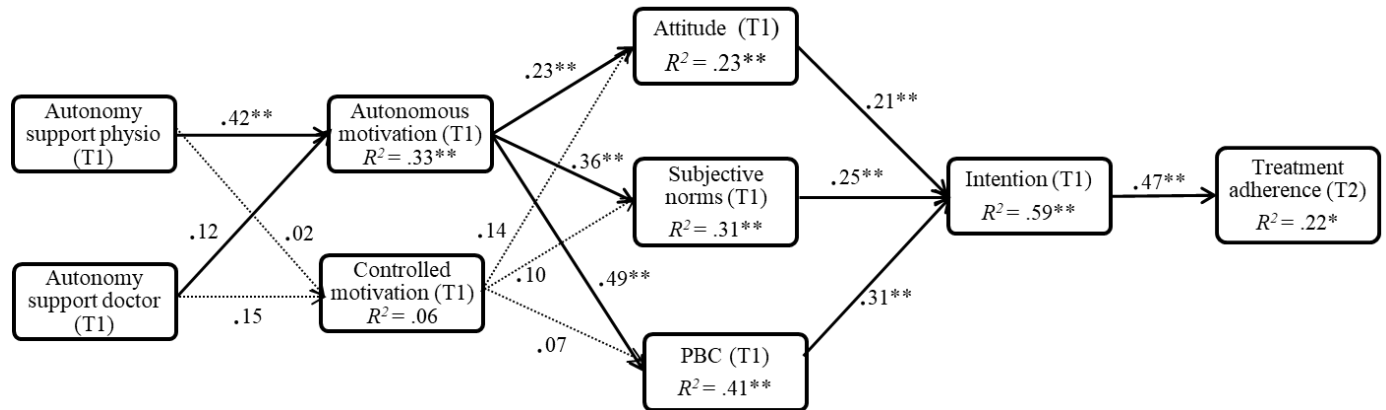


Fig 1. Integrated model for ACL rehabilitation adherence.

Note. Path estimates with solid lines were hypothesized to be positive and significant, and broken lines were hypothesized to be non-significant. Physio = Physiotherapist; PBC = Perceived Behavioural Control; T1 = Time 1; T2 = Time 2. \*  $p < .05$  \*\*  $p < .01$ .