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RESEARCH

Examining the Role Ones' Stage of Change Plays in Understanding the Relationship Between Motivation and Physical Activity

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Considerable research guided by the Self Determination Theory has demonstrated that people who are motivated by more self-determined reasons (e.g., enjoyment, core beliefs, or personally meaningful benefits) are more likely to be physical activity. However, far less is known about the role ones' stage of change (readiness for physical activity) plays in this relationship. The purpose of the present study was to (a) determine if the six forms of motivation and indices of physical activity varied across the stages of change, and (b) investigate if composite scores of self-determined and non-self-determined motivation were differentially related to physical activity indices depending on the stage of change of the individual. In total, 700 adults aged 18–65 (M_{age} = 32.59; *SD* = 12.82) completed an online survey consisting of demographics, and assessments of stages of change, motivation, and physical activity. Results demonstrated that participants at more advanced stages of change reported significantly higher self-determined motives, moderate activity, vigorous activity, and frequency of physical activity, and lower amotivation, with introjected regulation peaking at the implementation phase. Moderation analyses indicated that stages of change moderated the relationship between self-determined motives and moderate to vigorous physical activity, as well as physical activity frequency, but did not moderate the relationship between non-self-determined motives and indices of physical activity. Findings suggested that participants' self-determined motives play a critical role in physical activity and becomes more important at more advanced stages of change, which is important to consider for program and intervention development.

Keywords: Adults; health behaviour; moderator; quantitative methods; self determination theory; motives

Physical inactivity continues to prevail as a worldwide health concern, with approximately one in three adults failing to meet WHO's guidelines of 150 minutes of moderate to vigorous physical activity (PA) per week (WHO 2018). In response to this statistic, WHO put forth a "Global Action Plan on Physical Activity – 2018–2030" detailing a goal of reducing physical inactivity rates by 15% by 2030 (WHO 2018). To achieve this lofty goal, it is imperative to understand what differentiates inactive to habitually active individuals. One potential mechanism that may delineate individuals of varied PA habits is the motives that drive their actions.

Motivation

According to the Self Determination Theory (SDT), people are motivated for different reasons that vary in terms of quality (Ryan & Deci 2017). Six forms of regulations exist (Ryan & Deci 2017), including *intrinsic motivation* (e.g., for the inherent interest and enjoyment experienced from the behaviour itself), *integrated regulation* (e.g., because it is in line with one's core value), *identified regulation* (e.g., because the benefits of doing so are personally important), *introjected regulation* (e.g., to avoid feelings of shame, guilt, or for ego-enhancement), *external regulation* (e.g., to satisfy external pressure, achieve rewards or avoid punishment) and *amotivation* which represents a lack of motivation. Intrinsic motivation, integrated regulation, and identified regulation are classified as autonomous motives, while introjected regulation and external regulation are considered controlling motives. Extensive research across various contexts has providing evidence that autonomously guided behaviour consistently leads to desirable outcomes, while controlling motives tends to be associated with less optimal outcomes, with the direction and magnitude of these relationships being less consistent (e.g., Manganelli et al. 2018; Teixeira et al. 2012).

Within the PA context, two literature reviews which comprised of over 220 independent samples and spanned from childhood and adolescence (Owen et al. 2014) to adulthood (Teixeira et al. 2012) provided a detailed overview of the association between motivation and PA. In brief, the Relative Autonomy Index (RAI),[1] aggregate scores of autonomous motivation, intrinsic motivation, integrated regulation, and identified regulation – when considered individually – were positively associated with PA (Teixeira et al. 2012), reporting weak to moderate effect sizes (Owen et al. 2014). In contrast, the association between controlling motives – either as an aggregate score or individual motives – were far less consistent. The controlling motives (as a composite measure) and amotivation demonstrated negative relationships with PA, while external regulation reported a non-significant or weak negative effect size, and finally introjected regulation predominately reflected a positive association, albeit with a weak effect size (Owen et al. 2014; Teixeira et al. 2012). These reviews illustrated the advantageous nature of autonomous motives, and inconsistencies of controlling motives, which has been replicated in recent literature (e.g., Robertson et al. 2018), and highlighted considerations for future research. Recommendations include the need for studies to: (a) provide more detailed description and analysis of PA parameters (e.g., intensity, frequency, and type, and (b) examine additional moderating factors beyond age, and assessment tools (Owen et al. 2014; Teixeira et al. 2012).

Studies have additionally reported that while autonomous and controlling motives may drive an individual to start PA, only autonomous motives are significantly associated with long-term engagement (Teixeira et al. 2012). Therefore, it seems plausible that individuals at various stages of change (SOCs) (e.g., non-exerciser, exercise initiate or habitual exerciser) would differ not only on their PA, but also on the types of motivation that drive the activity. For example, individuals new to activity are likely to engage in less intense activity and experience more instability (Littell & Girvin 2002) – resulting in less consistency and frequency of activity. Those that don't exercise regularly may experience varied benefits (Warburton Nicol & Bredin 2006) and in turn motives for PA in comparison to those that are active on a regular basis. As such, it's probable that someone who has yet to begin being active would be less likely to be motivated by reasons of enjoyment (intrinsic motivation) or core beliefs and values (integrated regulation) in comparison to someone who is active on a regular basis. Thus, further investigation into the interplay between motivation, PA and SOC is warranted.

SOCs

Although there are several conceptualizations of SOC, the Stages of Change Model – the core of the Transtheoretical Model (TTM; Prochaska Reddings & Evers 2015) – is the most cited. While these SOCs were not the focus of the present research for reasons that will be explained, we have provided an overview of research related to this common approach. Five stages are categorised dependent on an individual's readiness to change, whether they are active or not, and the duration of their readiness or activity. The five stages are labeled as precontemplation, contemplation, preparation, action, and maintenance (Prochaska et al. 2015). In general, it is assumed that people in more advanced SOCs are likely to differ in their motives for PA from those in earlier SOCs (Ingledew Markland & Medley 1998).

Motivation, PA, and SOCs

At the crude level, the literature examining motivation and SOCs for PA/exercise has consistently demonstrated that people at more advanced SOCs tend to be driven by more autonomous motives (Teixeira et al. 2012). At the general level, more advanced SOCs have been characterised by a higher RAI and autonomous motives, and lower controlling motives (Buckworth et al. 2007; Daley & Duda 2006; Landry & Solmon 2004; Mullan & Markland 1997; Sit Kerr & Wong 2008; Thogersen-Ntoumani & Ntoumanis 2006). More specifically, this research has demonstrated significant differences in the positive direction for intrinsic motivation, enjoyment/interest, and identified regulation, with less consistent significant findings for introjected regulation in the positive direction and external regulation, and amotivation, in the negative direction. Scholars have articulated that controlling motives likely serve as the initial catalyst, which lead to autonomous motives and long-term adherence in the behaviour (Mullan & Markland 1997). Furthermore, Fortier and colleagues (2012) showed using a longitudinal design that Type 2 diabetes patients that

[1] Autonomy Index is frequently used in studies to weight the various forms of motivation along the continuum, while using only one score of motivation.

progressed through the stages of exercise change reported an overall increase in autonomous motivation, while non-progressors experienced a reduction in autonomous motivation. Given the differences in motivation between individuals of varied SOCs, it seems erroneous to investigate the relationship between motivation and PA using a heterogenous sample without considering the stage of change of the individual. Furthermore, with people at different SOCs likely to vary in the stability of their PA, and barriers they experience (e.g., knowledge or resources that may inform them of what or how to be active), it's probable that these differences may influence their activity levels regardless of how motivated they are.

The present study

The present study extended the literature by addressing several caveats. First, this research examined the moderating effect of SOCs on the relationship between motivation and PA following Owen and colleagues (2014) recommendation to test alternative moderators combined with Teixeira et al.'s (2012) review demonstrating that different types of motives vary by stage of change. Second, to provide more context on the nature of the PA based on previous recommendations (Owen et al. 2014), this study investigated moderate to vigorous physical activity (MVPA) – which is often the focus of most studies – as well as mild PA, and PA frequency. Third, the conceptualization of the SOCs within the TTM's Stages of Change Model has been the target of much scrutiny, with researchers criticizing the arbitrary timelines attached to various stages (Noar Benac & Harris 2007) – going so far as to attribute the lack of significant differences in results between the action and maintenance stage to these timelines (Rose Parfitt & Williams 2005). Furthermore, scholars have articulated that although stage-based interventions hold promise for facilitating behaviour change (Prochaska et al. 2015), researchers should utilise alternative stage models (Fortier et al., 2012). To address this call to action, the present study was guided by the Comprehensive Messaging Strategy Sustained Behaviour Change (CMSSBC; Pope Pelletier & Guertin 2018). The CMSSBC outlines five stages – detection, decision, implementation, maintenance, and habit. The *detection* phase is characterised by people who are either unaware of or fail to recognise the personal importance of PA and therefore are detecting whether it's relevant or important to them to be physically active (Pelletier & Sharp 2008; Pope Pelletier & Guertin 2018). People in the *decision* phase are aware of the importance (e.g., benefits) of PA, yet have not decided if they will personally take action to be physically active to address their PA incongruence (Pelletier & Sharp 2008; Pope Pelletier & Guertin 2018). The next stage, the *implementation* phase, is represented by people who have decided they will begin PA but may lack the knowledge of how to initiate the process to bridge the intentions – behaviour gap (Pelletier & Sharp 2008; Pope Pelletier & Guertin 2018). People in the *maintenance* phase have begun being physically active, yet, are working to maintain the behaviour long-term (Pope Pelletier & Guertin 2018). Finally, once an individual has reached the stage where they can maintain their PA habits, they are believed to be in the *habit* stage (Pope Pelletier & Guertin 2018). By using the SOC within the CMSSBC, the present study will eliminate the arbitrary timeline limitation acknowledged in previous research, while sustaining relatively similar SOCs, allowing us to compare the present study findings to previous literature with greater fluidity.

Finally, the present study examined each motivation individually – including integrated regulation – when testing motivation scores across each stage of change. This extends the literature which often (a) fails to include integrated regulation or (b) uses a RAI score or composite autonomous and controlling scores (Teixeira et al. 2012). Scholars have articulated the importance of understanding the shift in the types of motivation people experience across the SOCs to understand 'how' individuals progress in making their behaviours more habitual (Ingledew Markland & Medley 1998) and identify how to facilitate more optimal forms of motivation and sustained PA.

Purpose and hypotheses

The purpose of the present study was two-fold. First, this study determined if the six forms of motivation and indices of PA varied across the SOCs. Second, this study investigated if the relationship between composite scores of autonomous and controlling motivation with indices of PA were moderated by one's SOC. It was hypothesised that people in the later SOCs would report significantly higher levels of intrinsic motivation, integrated regulation, identified regulation, and PA in comparison to those self-identifying in the earlier SOCs. Consistent with the review by Teixeira et al. (2012), this trend was anticipated because people at more advanced stages of change identify the importance/relevance of PA, and therefore are more likely to engage in PA for internalized reasons consistent with intrinsic motivation, integrated regulation, and/or identified regulation. In contrast, because amotivation is essentially a lack of motivation, we anticipated that amotivation would decrease in progressively higher SOCs as people identify the importance/relevance of PA and begin PA. Due to the inconsistent findings pertaining to introjected and external regulation (Teixeira et al., 2012), no hypothesis was formulated regarding these motives. In reference to the second purpose, it was expected that because more intense and more frequent PA requires high quality motivation (Green-Demers Pelletier & Menard 1997), the frequency and the levels of intensity of PA would increase for the participants at the later SOCs as they report higher levels of autonomous motivation. Yet, we did not anticipate this moderating effect would persist in the relationship between controlling motives and PA.

Methods

Participants

After ethics were approved by the host institutions Research Ethics Board [2016–106], participants who provided consent were recruited to complete the online Qualtrics survey through convenience-based sampling and e-mail distribution to various clubs and organizations (e.g., sewing clubs, rotary clubs, gardening clubs, psychology research pool, etc.). Inclusion criteria for participating in the study were: (1) individuals aged 18–65, and (2) ability to read English fluently. Participants that completed the survey included 736 (n_{men} = 249; n_{women} = 483; $n_{transgender}$ = 3) adults aged 18–83 years old (M_{age} = 32.60; *SD* = 12.89). Participants self-identified as Caucasian (*n* = 615), Asian (*n* = 56), African (*n* = 17), Arabic (*n* = 5), Aboriginal/Metis (*n* = 10), biracial (*n* = 7), or other (*n* = 26). Participants self-reported their health as poor (*n* = 20), fair (*n* = 139), good (*n* = 292), very good (*n* = 227), or excellent (*n* = 57). BMI scores calculated from self-reported height and weight values averaged 26.30 (*SD* = 5.63) and were used to classify individuals as underweight (<18.5; *n* = 15), normal weight (18.5–24.9; *n* = 338), overweight (25–29.9; *n* = 220), or obese (≥ 30.0; *n* = 156) according to the Centers for Disease Control and Prevention (2020) criteria. Finally, 183 participants were labelled *insufficiently active*, 99 *moderately active*, and 451 were *active*.

Instruments

SOCs

Six items adapted from Guertin Pope and Pelletier's (2020) study in the nutrition context were used to assess SOCs for PA. The first item – used for data analyses purposes – asked participants to select the statement that most accurately represented their current thoughts about PA with a statement for each SOC listed in order thereafter, including; *detection* (I am *trying to decide if I should* be physically active), *decision* (I am *debating whether I am going to start* being physically active), *implementation* (I want to learn more about how (when, where, with whom) to be physically active), *maintenance* (I want to learn more about things I can do *to make regular physical activity part of my lifestyle*), and *habit* (Regular physical activity is already part of my lifestyle) phases. Items two through six – used as a validity check – each represented one of the above statements but were followed by a 7-point Likert response scale (1-*never* to 7-*always*). Items were reviewed and approved by the authors of the CMSSBC, thereby providing initial face validity. The original items (Guertin et al. 2020) demonstrated evidence of criterion validity in relation to self-determined motives, healthy eating, and unhealthy eating. In the present study, bivariate correlation scores between the Likert-based items demonstrated a simplex-ordered structure such that more proximal items (e.g., implementation and maintenance) were more strongly correlated with each other than more distal items (e.g., implementation and detection), thus providing initial support for the convergent validity of this scale. Further support for the validity of this scale was demonstrated by contrasting means for each of the last five items across the self-identified stages in item one, thus revealing that the means for the corresponding stage of change were higher for each self-identified stage. See **Table 1** for detailed findings pertaining to the descriptive statistics and bivariate correlations of the SOCs items.

Table 1: Descriptive Statistics and Associations between SOCs.

	M ± *SD*	*Skew./Kurt*	Decision	Implementation	Maintenance	Habit
Detection	3.63 ± 1.97	0.03/1.17	.76*	.47*	.40*	−.33*
Decision	3.72 ± 1.96	−0.05/−1.19		.54*	.44*	−.53*
Implementation	4.16 ± 1.90	−0.22/−1.01			.71*	−.33*
Maintenance	4.46 ± 1.92	−0.42/−0.91				−.21*
Habit	4.63 ± 1.94	−0.29/−1.13				

Note: *M* = Mean; *SD* = Standard Deviation; Skew./Kurt. = Skewness/Kurtosis. Significant relationships ($p \leq .01$) denoted with "*".

Motivation

Participants' motivation for PA was assessed with a previously used (Guertin, et al., 2017) 6-item scale adapted from Sheldon and Elliot (1999) that asked participants to indicate the extent to which each statement corresponded to the reasons they participated in PA.[2] The items represented *intrinsic motivation* (purely for the interest and enjoyment in doing physical activity), *integrated regulation* (interesting or not, I felt that it expresses my true values), *identified regulation* (because it's important to me to improve my fitness and health), *introjected regulation* (because I made myself do it to avoid shame or guilt), *external regulation* (because something about my external situation forced me to do physical activity), and *amotivation* (I have no idea why I do physical activity). Participants responded to these six items using a 7-point Likert scale that ranged from 1 (*does not correspond at all*) to 7 (*corresponds exactly*). Orthogonal (Varimax) rotation factor analyses demonstrated that a 2-factor structure was prevalent, with the three autonomous items loading on the first factor (factor loadings ranged from .710–.783) and the two controlling items loading on the second factor (factor loadings ranged from .821–.850). Eigenvalue scores indicated that the two factors accounted for approximately 36% and 26% of the variance, and Bartlett's test of sphericity demonstrated that the overall correlation matrix was significant (χ^2 (10), = 447.19; $p < .001$). The intrinsic, integrated, and identified items were computed into an aggregate score of autonomous motives ($\alpha = 0.62$), while the introjected and external items signified controlling motives[3] as per previous literature (Vansteenkiste et al. 2005).

PA

Participants' self-reported PA level during a typical 7-day period was assessed using Godin's Leisure Time Exercise Questionnaire (Godin & Shephard 1985). Participants were prompted to indicate the frequency they engaged in bouts of 15 minutes of strenuous, moderate, and mild activity with one item each. A composite score of MVPA represented as "units" was derived using the recommended calculation (strenuous activity × 9 + moderate activity × 5; Amireault & Godin 2015). Individuals with scores of 24 units or more (≥14 kcal/kg/week) were considered "active", those with scores between 14 and 23 units (7–13.99 kcal/kg/week) were labelled "moderately active", while participants with scores less than 14 units (<7 kcal/kg/week) were labelled "insufficiently active". Additionally, participants indicated the frequently of their PA using a Likert-scale ranging from 1 (*often*) to 3 (*rarely*) which was reverse coded for this study.

Data analyses

A 6-step iterative data analyses process using SPSS Statistical Software (Version 27.0; SPSS, Inc., Armonk, NY, USA) followed. First, missing values analyses (Little 1988) were performed to screen for missing and incomplete data. Second, data were screened to identify out-of-range scores, univariate and multivariate outliers, and assess normality. Third, subscale scores were computed for autonomous motives, controlling motives, and MVPA. Fourth, bivariate correlation scores (Pearson correlation *r*) were computed to determine associations between constructs. Fifth, MANOVAs were conducted, and effect sizes were calculated. Sixth, two simple moderation models were tested using the SPSS PROCESS macro (Hayes 2013) with bootstrapping (samples = 5000).

Results

The initial sample of 736 participants was reduced to 724 after participants were removed because they failed to provide consent ($n = 1$), did not meet the specified age range (18–65; $n = 2$), or failed to complete an entire section ($n = 9$). Thereafter, Little's Missing Completely at Random (MCAR) test was employed across the PA, motivation, and SOC variables which indicating 0.67% of the data were considered "missing completely at random"; $\chi^2(265) = 267.89$, $p < .05$. Expectation maximization scores were computed and replaced for missing data.

Preliminary analyses

To begin, 24 participants were removed due to multivariate ($n = 14$) or univariate outliers ($n = 10$) for the PA variables. Tests of normality were performed, and results of the Shapiro-Wilk's test demonstrated that all variables (SOCs, autonomous motives, controlling motives, MVPA, and frequency) were not normally

[2] This single-item subscale measure was selected over scales that have underwent more psychometric testing to reduce participant burden as this was part of a larger survey that took approximately 45 minutes to complete. As such, we presented psychometric testing of this scale within the present sample.

[3] Autonomous and controlling subscales were used in the moderation analyses to minimise multicollinearity issues reported when separate motives are used, while ensuring that similar motives were grouped together (Brunet et al. 2015). Amotivation was not included in the controlling subscale as it is a lack of motivation.

Table 2: Descriptive Statistics and Associations between SOC, Motives, and PA Indices.

	M ± *SD*	*Skew./Kurt.*	1	2	3	4	5	6	7	8	9	10	11	12	13
1. SoC															
2. Intrinsic	4.57 ± 1.75	–0.47/–0.54	.39*												
3. Integrated	3.61 ± 1.72	0.10/–0.77	.33*	.42*											
4. Identified	5.89 ± 1.24	–1.29/1.62	.31*	.26*	.38*										
5. Introjected	3.27 ± 1.75	0.30/–0.90	–.02	–.01	.24*	.06									
6. External	3.54 ± 1.78	0.15–0.90	–.01	.06	.17*	.07+	.42*								
7. Amotivation	1.67 ± 1.22	2.07/4.03	–.21*	–.10*	.01	–.28*	.14*	.11*							
8. Aut. motives	4.69 ± 1.19	–0.39/0.05	.45*	.78*	.82*	.66*	.13*	.13*	–.14*						
9. Cont. motives	3.41 ± 1.49	0.12/–0.70	–.01	.03	.24*	.07	.84*	.85*	.15*	.15*					
10. Mild PA	4.20 ± 3.60	2.10/9.58	.01	.04	–.02	.01	–.01	–.04	–.02	.02	.03				
11. Moderate PA	2.87 ± 2.61	1.13/1.81	.27*	.21*	.16*	.15*	.04	.00	–.04	.23*	.03	–.02			
12. Strenuous PA	3.41 ± 1.49	0.12/–0.70	.51*	.36*	.32*	.22*	–.01	.00	–.09+	.40*	.00	.31*	.24*		
13. MVPA	25.65 ± 0.71	0.71/0.25	.52*	.38*	.32*	.24*	.02	.00	–.09+	.42*	.01	.14*	.69*	.87*	
14. PA frequency	0.78 ± 0.16	–0.16/–1.36	.60*	.35*	.37*	.27*	.04	.02	–.14*	.44*	.03	.03	.34*	.64*	.66*

Note: *M* = Mean; *SD* = Standard Deviation; Skew./Kurt. = Skewness/Kurtosis; Aut. motives = Autonomous motives; Cont. motives = Controlling motives; variables 2–9 ranged from 1–7, mild PA ranged from 0–30, Moderate PA ranged from 0–15, Strenuous PA ranged from 0–10, MVPA ranged from 1–115, and PA frequency ranged from 1–3. Significant relationships ($p \leq .01$) denoted with "*", and significant relationships ($p \leq .05$) denoted with a "+".

distributed.[4] Participants self-identified as being in the detection ($n = 18$), decision ($n = 83$), implementation ($n = 83$), maintenance ($n = 231$), or habit ($n = 285$) SOCs. In general, participants scored higher on autonomous versus controlling motives and PA indices scores indicating this sample to be relatively active. See **Table 2** for descriptive statistics.

Associations between SOCs, motives, and indices of PA

Inspection of the bivariate correlations scores demonstrated that all individual autonomous motives and the corresponding composite score were significantly and positively associated with SOCs, moderate PA, strenuous PA, MVPA, and PA frequency at the moderate level, but not mild PA. In contrast, the composite controlling motive subscale, introjected regulation, and external regulation were not significantly correlated with SOCs, or any PA indices, while amotivation demonstrated a significant negative relationship with SOCs, strenuous PA, and MVPA. See **Table 2** for the bivariate correlation scores.

Comparing varied self-identified SOCs

One-way MANOVAs were conducted comparing motives and indices of PA across SOCs. Due to the limited number of participants in the detection phase ($n = 18$), the detection and decision phase were combined.[5] Considering that the data were not normally distributed for most of the variables, and group sizes varied considerably, *Pillai's Trace* was used (Tabachnick & Fidell 2013; Tomarken & Serlin 1986). Partial eta-squared (η_p^2) effect sizes were calculated for main effects, with scores greater than 0.06 generally considered medium, and scores greater than 0.14 interpreted as large (Miles & Shevlin 2001). Thereafter, individual comparisons

[4] Data weren't transformed as PROCESS macro does not require normality assumption (Hayes 2013).

[5] This approach has been frequently utilised in previous studies assessing SOCs guided by the TTM in the exercise context (Daley et al., 2006; Mullan and Markland, 1997; Rose et al., 2005) as the first stage (pre-contemplation) is often under-represented.

were inspected, and the unbiased *Hedge's g* effect sizes were calculated when significant *Games-Howell* test scores were observed (Rosnow & Rosenthal 2003).

Differences in motives and PA between participants self-identified SOC

MANOVA results indicated a statistical significant main effect for stage of change on the various forms of motivation ($F_{(18, 2067)}$ = 12.42, p < .001, Pillai's Trace = 0.29, η_p^2= 0.091). Follow-up univariate analyses demonstrated significant differences for all PA motives, except external regulation. Post-hoc Games-Howell analyses identified numerous significant pairwise differences (see **Table 3** for a detailed MANOVA report). In relation to SOCs on PA outcomes (mild, moderate, strenuous, and frequency), a statistical significant main effect was reported ($F_{(12, 2085)}$ = 31.30, p < .001, Pillai's Trace = 0.46, partial η^2 = 0.15). Follow-up univariate analyses demonstrated significant differences for moderate PA, strenuous PA, and PA frequency, but not for mild frequency. See **Table 4** for a detailed MANOVA report.

Table 3: MANOVAS: Differences in PA Motives across SOCs.

	Det./Dec *M* ± SD	Implementation *M* ± SD	Maintenance *M* ± SD	Habit *M* ± SD	*Pillai's Trace;* η_p^2
Intrinsic	3.42 ± 1.84	3.94 ± 1.60	4.31 ± 1.62	5.38 ± 1.46	F = (3, 696) = 41.52; $p \le$ .001, η_p^2 = 0.18
Detection/decision – Maintenance: Games-Howell (ΔM = −0.89), p ≤ .001, g = –0.53 (95% CI = –0.71, –0.34)					
Detection/decision – Habit: Games-Howell (ΔM = –1.97), p ≤ .001, g = –1.25 (95% CI = –1.40, –1.09)					
Implementation – Habit: Games-Howell (ΔM = –1.44), p ≤ .001, g = –0.96 (95% CI = –1.12, –0.28)					
Maintenance – Habit: Games-Howell (ΔM = 1.08), p ≤ .001, g = –0.70 (95% CI = –0.83, –0.56)					
Integrated	2.59 ± 1.38	3.17 ± 1.42	3.47 ± 1.63	4.22 ± 1.75	F = (3, 696) = 5.64; $p \le$ .001, η_p^2= 0.11
Detection/decision – Implementation: Games-Howell (ΔM = –0.58), p ≤ .05, g = –0.41 (95% CI = –0.62, –0.21)					
Detection/decision – Maintenance: Games-Howell (ΔM = –0.88), p ≤ .001, g = –0.56 (95% CI = –0.70, –0.40)					
Detection/decision – Habit: Games-Howell (ΔM = –1.63), p ≤ .001, g = –0.98 (95% CI = –1.15, –0.81)					
Implementation – Habit: Games-Howell (ΔM = –1.05), p ≤ .001, g = –0.62 (95% CI –0.80 = –0.45)					
Maintenance – Habit: Games-Howell (ΔM = –0.88), p ≤ .001, g = 0.44 (95% CI = 0.59, 0.30)					
Identified	5.04 ± 1.48	5.70 ± 1.11	5.93 ± 1.23	6.22 ± 1.03	F = (3, 696) = 23.87; $p \le$ .001, η_p^2= 0.10
Detection/decision – Implementation: Games-Howell (ΔM = –0.66), p ≤ .05, g = –0.50 (95% CI = –0.69, –0.30)					
Detection/decision – Maintenance: Games-Howell (ΔM = –0.89), p ≤ .001, g = –0.68 (95% CI = –0.82, –0.54)					
Detection/decision – Habit: Games-Howell (ΔM = –1.18), p ≤ .001, g = –1.01 (95% CI = –1.13, –0.90)					
Implementation – Habit: Games-Howell (ΔM = –0.52), p ≤ .001, g = –0.50 (95% CI = –0.60, –0.39)					
Maintenance – Habit: Games-Howell (ΔM = –0.29), p ≤ .001, g = –0.26 (95% CI = –0.36, –0.16)					
Introjected	2.94 ± 1.60	3.72 ± 1.82	3.53 ± 1.68	3.05 ± 1.80	F = (3, 696) = 5.64; p < .001, η_p^2= 0.03
Detection/decision – Implementation: Games-Howell (ΔM = –0.78), p ≤ .05, g = 0.42 (95% CI = 0.70, 0.21)					
Detection/decision – Maintenance: Games-Howell (ΔM = –0.59), p ≤ .05, g = 0.36 (95% CI = 0.53, 0.00)					
Implementation – Habit: Games-Howell (ΔM = 0.67), p ≤ .05, g =0.37 (95% CI = 0.18, 0.55)					
Maintenance – Habit: Games-Howell (ΔM = 0.48), p ≤ .01, g = 0.27 (95% CI = 0.12, 0.43)					
External	3.38 ± 1.65	3.70 ± 1.72	3.72 ± 1.70	3.40 ± 1.90	F = (3, 696) = 1.68; p > .05, η_p^2= 0.01
Amotivation	2.16 ± 1.46	2.00 ± 1.36	1.60 ± 1.05	1.46 ± 1.13	F = (3, 696) = 9.43; p < .001, partial η^2 = 0.05
Detection/decision – Maintenance: Games-Howell (ΔM = 0.56), p ≤ .01, g = 0.47 (95% CI = 0.34, 0.60)					
Detection/decision – Habit: Games-Howell (ΔM = 0.70), p ≤ .001, g = 0.57 (95% CI = 0.45, 0.69)					
Implementation – Habit: Games-Howell (ΔM = 0.54), p ≤ .01, g = 0.46 (95% CI = 0.33, 0.58)					

Note: Means, standard deviations, *Pillai's Trace*, and η_p^2 are presented in a single row for each stage of change followed by each individual significant comparison and the corresponding effect size using Hedge's g.

Table 4: MANOVAS: Differences in PA Indices across SOCs.

	Det./Dec *M* ± SD	Implementation *M* ± SD	Maintenance *M* ± SD	Habit *M* ± SD	*Pillai's Trace;* η_p^2
Mild PA	3.81 ± 3.62	4.57 ± 3.97	4.36 ± 3.25	4.08 ± 3.74	F(3, 696) = 0.96, p > .05; η_p^2 = .004
Moderate PA	1.61 ± 1.96	2.36 ± 2.66	2.61 ± 2.51	3.68 ± 2.63	F(3, 696) = 20.14, p ≤ .001; η_p^2 = .080
Detection/decision – Maintenance: Games-Howell (ΔM = −1.01), p ≤ .001, g = –0.42 (95% CI = –0.68, –0.17)					
Detection/decision – Habit: Games-Howell (ΔM = –2.06), p ≤ .001, g = –0.84 (95% CI = –1.08, –0.59)					
Implementation – Habit: Games-Howell (ΔM = –1.32), p ≤ .001, g = –0.09 (95% CI –0.38, 0.18)					
Maintenance – Habit: Games-Howell (ΔM = –1.06), p ≤ .001, g = 0.00 (95% CI = –0.22, 0.23)					
Strenuous PA	0.47 ± 0.95	0.63 ± 1.10	1.51 ± 1.74	3.39 ± 2.12	F(3, 696) = 107.27, p ≤ .001; η_p^2 = 0.32
Detection/decision – Maintenance: Games-Howell (ΔM = –1.04), p ≤ .001, g = –0.67 (95% CI = –0.84, –0.51)					
Detection/decision – Habit: Games-Howell (ΔM = –2.92), p ≤ .001, g = –1.55 (95% CI = –1.73, –1.36)					
Implementation –Maintenance: Games-Howell (ΔM = –0.88), p ≤ .001, g = –0.55 (95% CI = –0.73, –0.37)					
Implementation – Habit: Games-Howell (ΔM = –2.77), p ≤ .001, g = –1.42 (95% CI = –1.62, –1.22)					
Maintenance – Habit: Games-Howell (ΔM = –1.89), p ≤ .001, g = –0.96 (95% CI = –1.13, –0.79)					
PA frequency	1.35 ± 0.54	1.58 ± 0.61	1.91 ± 0.69	2.65 ± 0.56	*F*(3, 696) = 157.38, *p* ≤ .001; η_p^2 = 0.40
Detection/decision – Maintenance: Games-Howell (ΔM = –0.57), p ≤ .001, g = –0.86 (95% CI = –0.93, –0.79)					
Detection/decision – Habit: Games-Howell (ΔM = –1.30), p ≤ .001, g = –2.34 (95% CI –2.39, –2.28)					
Implementation –Maintenance: Games-Howell (ΔM = –0.34), p ≤ .001, g = –0.49 (95% CI = –0.57, –0.42)					
Implementation – Habit: Games-Howell (ΔM = –1.07), p ≤ .001, g = –1.87 (95% CI = –1.93, –1.81)					
Maintenance – Habit: Games-Howell (ΔM = –0.74), p ≤ .001, g = –1.25 (95% CI –1.31, –1.19)					

Note: Means, standard deviations, *Pillai's Trace*, and η_p^2 are presented in a single row for each stage of change, followed by each individual significant comparison and the corresponding effect size using Hedge's.

Moderation analyses

The PROCESS macro in SPSS was used to determine if SOCs served as a moderating variable when examining the relationship between motivation and PA indices. This function categorises the moderating variable into three categories (–1 SD, 0, and +1SD), which resulted in participants being grouped as follows: *detection/decision* + *implementation* – "low"; *maintenance* – "moderate"; *habit* – "high". Results indicated that autonomous motives (*b* = 4.90, *SE* = 0.75, *p* ≤ 0.001, 95% *CI* [3.42, 6.37]), SOCs (*b* = 11.07, *SE* = 0.88, *p* ≤ 0.001, 95% *CI* [9.35, 12.78]), and the interaction variable (*b* = 1.85, *SE* = 0.63, *p* ≤ 0.005, 95% *CI* [0.62, 3.08]) were all significantly associated with MVPA, accounted for 33% of the variance ($F_{(3, 696)}$ = 114.47, *p* ≤ 0.001), with the addition of the interaction accounting for 0.85% of the variance. In contrast, SOCs (*b* = 13.01, *SE* = 0.79, *p* ≤ 0.001, 95% CI [11.46, 14.55]) was significantly related to MVPA while controlling motivation (*b* = 0.35, *SE* = 0.55, *p* > 0.05, 95% CI [–0.73, 1.44]) and the interaction term weren't significantly linked to MVPA (*b* = 0.10, *SE* = 0.54, *p* > 0.05, 95% *CI* [–0.95, 1.16]), accounting for 28% of the variance (*F* (3, 696) = 91.71, *p* ≤ 0.001). See **Figure 1** for simple slopes results.

Moderation analyses were also performed with PA frequency as the dependent variable. Accounting for 17% of the variance ($F_{(3, 696)}$ = 114.47, *p* ≤ 0.001), autonomous motives (*b* = 0.14, *SE* = 0.02, *p* ≤ 0.001, 95% CI [0.10, 0.18]), SOCs (*b* = 0.08, *SE* = 0.02, *p* ≤ 0.001, 95% CI [0.36, 0.11]), and the interaction variable (b = 0.08, se = 0.03, *p* ≤ 0.05, 95% CI [0.02, 0.14]) were all significantly related to PA frequency, with the moderator accounting for 1.32% of the variance. Similar to MVPA, only SOCs (*b* = 0.46, *SE* = 0.03, *p* ≤ 0.001, 95% *CI* [0.41–0.50]) was significantly associated with PA frequency when controlling motivation (*b* = 0.02, *SE* = 0.02, *p* > 0.05, 95% CI [–0.01, 0.05]) was used in the model, with no moderation effect illustrated (*b* = –0.01, *SE* = 0.02, *p* > 0.05, 95% CI [–0.04, 0.02]). These variables accounted for 37% of the variance of PA frequency ($F_{(3, 696)}$ = 139.26, *p* ≤ 0.001). See **Figure 1** for simple slopes results.

Discussion

Overall, the purpose of this study was to (a) test whether indices of PA and SDT's six forms of motivation differed across the SOCs, and (b) determine if SOC moderated the relationship between autonomous and controlling motivation with indices of PA. In line with our hypothesis and previous literature

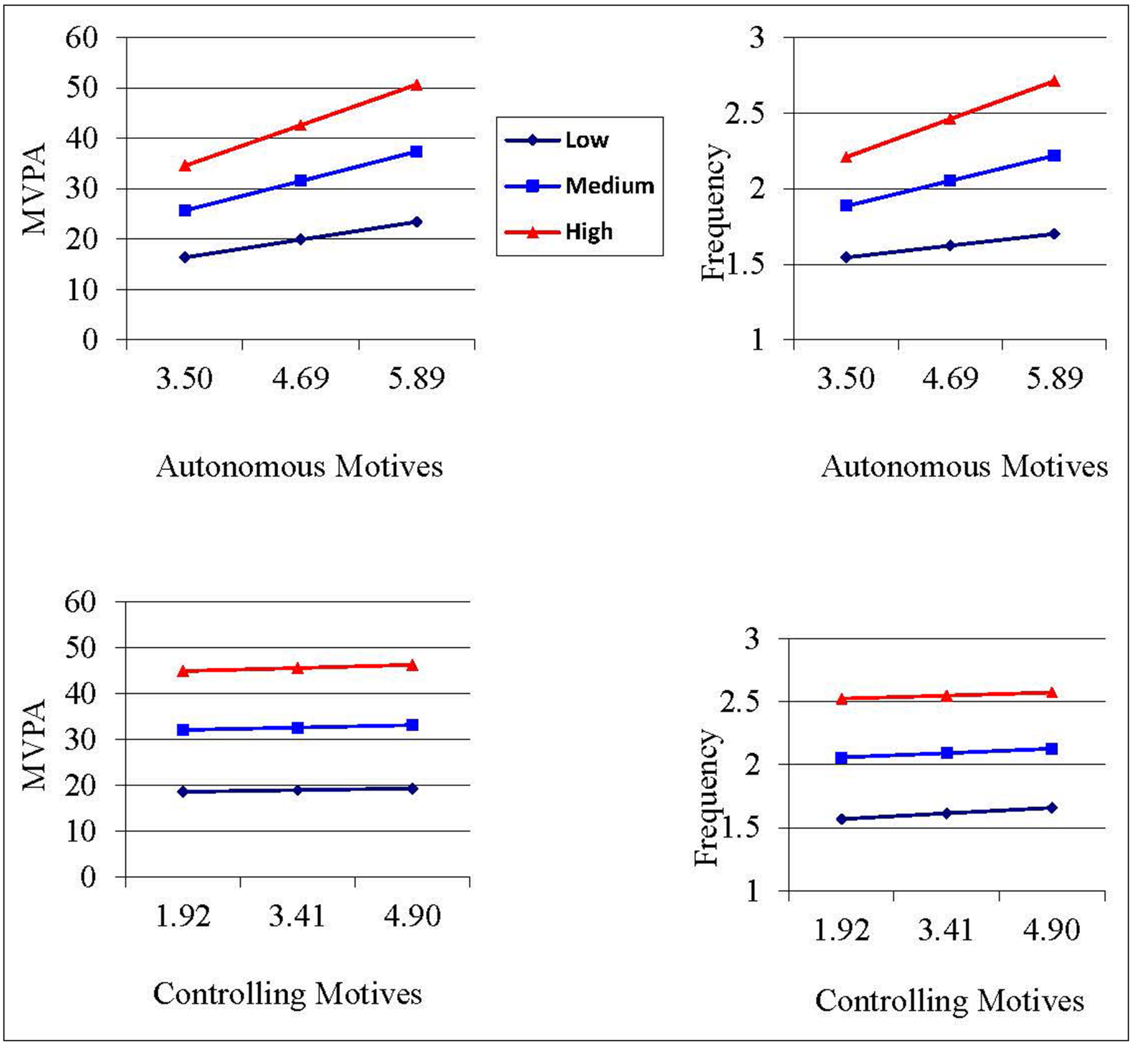

Figure 1: Simples Slops for Regression Analyes with Moderation.

(Teixeira et al. 2012), participants in the later SOCs reported significantly higher autonomous motives, MVPA, and PA frequency, but not mild PA, compared to those in less advanced SOCs. Study findings pertaining to the second purpose also supported our hypotheses. Autonomous motivation was significantly related to MVPA and PA frequency, with SOCs moderating the relationship between autonomous motivation and PA indices. Furthermore, post-hoc analyses demonstrated that people at more advanced SOCs were more likely to report higher indices of PA at a given level of autonomous motivation. In contrast, controlling motivation was not significantly associated with MVPA or PA frequency, and this relationship was not moderated by SOCs.

Findings testing the first purpose significantly contributes to the literature by extending previous studies that either utilised a composite RAI (Landry & Solmon 2004; Mullan & Markland 1997), used alternative operationalisations of motivation which did not specifically tap the six motives within SDT (Buckworth et al. 2007; Sit Kerr & Wong 2008), or failed to include integrated regulation (Daley et al., 2006; Thogersen-Ntoumani & Ntoumanis 2006; Wininger 2007). Similar to those studies that included all six motives independently (Daley et al. 2006; Thogersen-Ntoumani & Ntoumanis 2006; Wininger, 2007), results indicated that on average, identified regulation was the most salient reason why people engaged in PA, regardless of their SOC, with this motive and intrinsic motivation increasing for people in progressively higher SOCs. Similarly, integrated regulation was more prominent for people in progressively higher SOCs; however, participants reported their PA was regulated least by integrated reasons in all stages except the habit stage, with the exception of amotivation. Based on these findings, one can conclude that people in earlier SOCs may benefit more from interventions that help to internalise PA into one's lifestyle and make it enjoyable in order to optimise higher intensity activity and more frequent bouts of activity. In addition to MVPA, which is often the focus of studies, this study indicated that the frequency of the activity is important to consider.

In relation to the controlling motives, previous research has demonstrated that introjected regulation increased for individuals in higher SOCs (Daley et al. 2006; Thogersen-Ntoumani & Ntoumanis 2006; Wininger 2007) while external regulation reported non-significant differences (Daley et al 2006; Thogersen-Ntoumani & Ntoumanis 2006) or increased for people in the pre-contemplation until preparation stages and decreasing thereafter (Wininger 2007). Our results differed marginally in that both introjected and external regulation increased to a certain point, then decreased thereafter (introjected regulation peaked at the implementation phase, while external regulation peaked at the maintenance phase). The inconsistent findings pertaining to the interplay between controlling motives and SOCs parallel previous research (see Teixeira et al. 2012 for a review). While the reason for this variability is unknown, one could speculate these differences may be due to the measures utilized or the complex nature of participants motivation profiles across the studies. SDT research (Ryan & Deci 2017) has repeatedly illustrated that individuals are simultaneously motivated toward a behaviour for various reasons – which may include any combination of the six forms of motivation along the SDT continuum. Therefore, it may be the amount of introjected/external regulation one experiences in relation to the other forms of motivation (e.g., intrinsic motivation, identified regulation, or amotivation) that explains the association with indices of PA. This highlights the need to continue to test the controlling motives individually – and using more sophisticated methods such as motivation profiles or cluster analyses – to decipher the potential impact of introjected regulation (e.g., guilt, ego-enhancement, shame) and external regulation (e.g., appearance, social pressure) on PA – which are continuously emphasized within mainstream media.

A critical implication of the present study concerns the importance of distinguishing participants' SOCs when examining the relationships between motivation (specifically autonomous motivation) and PA. When all individuals are grouped together, without any distinction in their SOCs, the relationships between motivation and PA may be attenuated to a point where it may be difficult to detect or to reach statistical significance. However, when participants' SOCs are considered, the relationships between specific motives and PA may emerge more systematically as participants reach higher SOCs. The second implication derived from this research recognizes the value of identifying research participants' SOCs. If a sample is composed of individuals that are mainly at the detection or decision phases, the relationships between different types of motivation and PA may be weaker or not representative of future behaviours. However, if a sample is composed of individuals primarily at the maintenance of habit stages, the relationships between the different types of motivation and indices of PA may not only be more significant, but they may also show patterns more consistent with hypotheses derived from the SDT.

The final implication we perceive could be derived from this study is that it highlights the value of identifying one's SOC for guiding the selection of dependent variables relevant to specific stages. For instance, at the detection and decision stages, participants may show intentions of being active, they may be more inclined to read more on the topic or to search information on what to do and how to do it, but they may show low levels of PA or inconsistent patterns of PA itself. When at the implementation stage, factors of interest may be the extent to which participants plan their behaviour, or plan to remove the obstacles that could interfere with the practice of PA. Critical dependent variables in the maintenance and habit stages, could then be the amount of PA done on a regular basis, its intensity, or its level of complexity. If a researcher is interested in examining the health benefits of being physically active, it would make sense then to hypothesise that participants at the early stages of change may not show any relationships between the amount of PA done and indices of physical health (ex., body mass index, percentage of body fat, strength, physical fitness) when compared to participants at the more advanced SOC. Participants that are at the maintenance or habit stages of change may not only show more systematic patterns of PA, but the health benefits – particularly long-term benefits – that theoretically should be associated with PA.

Limitations and future research

As with any research, the present study was bound by some limitations. This study was limited to cross-sectional, self-report data, which may lead to social desirability biases and limits causal inferences. Second, despite considerable efforts to recruit a diverse sample, with emphasis on individuals in earlier SOCs, the early stages (2.48% detection phase, 11.46% decision phase, 11.46% implementation phase) may have been under-represented in comparison to the final stages (31.91% maintenance phase; 38.81%). This trend is not uncommon within the literature and has been reported in several papers (Daley & Duda 2006; Mullen & Markland 1997; Rose et al. 2006). Although we would not expect this misrepresentation to influence the relationship between SOCs and PA, a larger sample size in the earlier stages could provide us with more confidence that the difference in individual forms of motivation – particularly external regulation – across the SOCs are representative of the general population. Additionally, is it important to note that the present sample was relatively active, which likely reflects a self-selection bias (tendency for active people to participate in a study about PA) and therefore reduces the generalizability to the less active general population. Third, the SOCs and different forms of motivation were each measured using single items. Although this decision was made to reduce the burden on participants whom completed a long survey, the inclusion of these measures limited our ability to assess the reliability of the scales and may have influenced the degree to which these constructs were fully represented. Thus, it is recommended, that future replication studies consider the possibility of using multiple items to measure the proposed constructs to improve the reliability of the measures. Furthermore, this study was the first to test the alternative conceptualization of SOCs (Pope Pelletier & Guertin 2018) and use a newly designed scale to measure these SOCs in the PA context. The psychometric testing within this study provided initial evidence that it may be a viable option for assessing SOCs, yet further testing must be employed to determine the validity and reliability of this measure.

In conclusion, the present study suggests that participants' autonomous motivation plays a critical role in understanding PA. However, this role should be examined more systematically by taking into consideration the participants' SOCs, while utilizing a longitudinal design, and examining other important factors (e.g., intentions, information seeking, planning). SOCs may not only be useful in understanding the process through which people change, it may also be important to understand how motivation differentially relates to PA.

Data Accessibility Statement
The data repository can be found here: https://hdl.handle.net/10133/5928

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Competing Interests
The authors have no competing interests to declare.

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