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A Pilot Study on In-Task Affect Predicting Free-Living Adherence to HIIT and MICT

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ABSTRACT

Purpose: To report pilot test findings on whether in-task affect during a supervised exercise program, where participants were randomized to either moderate-intensity continuous training (MICT) or high-intensity interval training (HIIT), predicts changes in moderate-to-vigorous physical activity (MVPA-Total and MVPA10+ in bouts of ≥ 10 min) at 1- and 6-month post-intervention. **Method**: This experimental study design randomized 32 inactive adults with prediabetes to complete a 2-week supervised MICT or HIIT plus behavioral counseling exercise intervention and objectively assessed free-living physical activity post-intervention. The Feeling Scale (FS) was used to assess the in-task effect. FS was measured in the middle of four, 1-min intervals in the HIIT condition, corresponding to ~20%, ~50%, ~75%, and ~85% of work out time. For the MICT condition, FS was assessed at similar exercise duration percentage times as HIIT. Accelerometer data evaluated MVPA at 1- and 6-month post-intervention. **Results**: 32 adults were included in the analyses. Pilot findings indicated in-task affect between the conditions did not predict changes in MVPA-Total from baseline to 1 and 6 months. For MVPA10+, in-task affect negatively predicted MVPA10+ over time in the MICT condition only. **Conclusion**: This study provides preliminary evidence that affect during MICT negatively predicts MVPA10+ over time, and that there is no difference of in-task affect's utility in predicting MVPA-Total between HIIT and MICT. Larger studies are required to confirm these findings.

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Accelerometer; affect; exercise; Feeling Scale

American College of Sports Medicine physical activity guidelines recommend healthy adults accumulate at least 150 minutes of moderate-intensity exercise per week, or 75 minutes of vigorous-intensity exercise per week (Garber et al., 2011). Unfortunately, less than 5% of American adults reach this recommendation (Troiano et al., 2008). Physical inactivity places individuals with prediabetes at even higher risk for developing chronic health conditions such as type 2 diabetes or cardiovascular disease. Individuals at risk for diabetes are therefore important sample to be included in physical activity research that aims to understand and address inactivity for two reasons. Adults with prediabetes are a low active and a high-risk population to develop chronic health condition(s) (Gerstein & Meltzer, 1999). Second, prediabetes is highly prevalent in North America, with 34.5% of adults living with prediabetes (Centers for Disease Control and Prevention, 2020).

The promotion of moderate-intensity exercise engagement is suggested as means to address the low exercise adherence rates because presumably it is perceived as a pleasurable form of activity: "Moderate-intensity exercise and exercise that is enjoyable can enhance the affective responses to exercise, and *may* [emphasis added] improve exercise adherence" (Garber et al., 2011, p. 1335). To date, however, there is no randomized study design that has provided empirical evidence to support the assertion that affect elicited through moderate-intensity continuous exercise (MICT), as compared to affect elicited through higher-intensity interval training (HIIT) exercise, predicts greater free-living exercise adherence in low-active adults. HIIT involves engaging in brief bouts of high-intensity exercise (e.g., >80% of maximal heart rate), interspersed with lighter-intensity exercise (Gibala & McGee, 2008; Weston et al., 2014).

The state of the literature on affective responses elicited through exercise and long-term physical activity, however, reflects the overall use of non-experimental methods and self-report recall (e.g., Rhodes & Kates, 2015; Williams et al., 2008, 2012). This limits the conclusions that can be drawn on whether moderate-intensity indeed needs to be promoted over alternative, higher intensity exercise options because the former is associated with more pleasurable or enjoyable outcomes. Rhodes and Kates (2015) synthesized the literature on

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the relationship between in-task affect and post-exercise affect and future physical activity behavior. The review included 24 papers, four of which examined in-task affect. Affect during moderate-intensity exercise was found to be positively associated with future self-report physical activity (Kwan & Bryan, 2010; Williams et al., 2012) and accelerometry assessed moderate-intensity physical activity (Schneider et al., 2009), but not high-intensity physical activity (Schneider et al., 2009). Prominent studies by Williams et al. (2012), Williams et al. (2008)) show that more pleasant affect during exercise, or in-task affect, is associated with more minutes of physical activity over time. Of note is that the findings are based on associations over time and not experimental evidence. In-task affect was measured during a treadmill test in the laboratory until the participant reached their age-predicted maximum heart rate (Williams et al., 2008) or during a 10-min walk test (Williams et al., 2012) and retrospective accounts of exercise behavior were recorded at 6 or 12 months later. Overall the review by Rhodes and Kates (2015) provides important initial evidence on the potential relationship between in-task affect and physical activity behavior that supports the theoretical assertion that in-task affect is determined from two factors that interact with one another: cognitive factors (e.g., exercise self-efficacy) and physiological (or interoceptive) feedback from the body (Ekkekakis, 2003). According to the Dual Mode Model, at lower intensities (< Ventilatory Threshold, or < VT) predominantly cognitive factors influence perceptions of how pleasant-unpleasant the exercise is perceived, while at higher intensities (> VT) most individuals report displeasure because in-task affect is largely determined by interoceptive feedback (Ekkekakis, 2003). Of note, however, is that the development of this model and thereby the empirical evidence driven by this model was based on *continuous* low, moderate, and high intensity exercise (> VT), and not considering alternative forms such as *intermittent* exercise that can include HIIT.

HIIT needs to be examined in relation to physical activity for two reasons. First, HIIT has been shown to elicit similar health benefits compared to other exercise modalities, such as moderate-intensity continuous exercise, often in less time (Gibala et al., 2014; Weston et al., 2014). Second, HIIT elicits different affective responses compared to continuous exercise (e.g., Oliveira et al., 2013). Their inherent differences may produce meaningful impact on how the exercise is perceived, and subsequently on exercise adherence.

Compared to moderate- and high-intensity *continuous* training, HIIT has been shown to have different effects on in-task affect (Decker & Ekkekakis, 2017; Oliveira et al., 2013). A study with young healthy men found that in-task affect during HIIT (100% of $V02_{peak}$ for 2 min, and recovery at intensity of 0%) was lower compared to high-intensity continuous training (85% of $V02_{peak}$; Oliveira et al., 2013). Another study, utilizing a counter-balanced cross-over design, with low-active adults who completed a single bout on a cycle ergometer at continuous moderate-intensity (~40% W_{peak} for 40 minutes), continuous vigorous-intensity exercise (20 minutes at an intensity of ~80% of W_{peak}), and HIIT (20 minutes, alternating between 1-min intervals at ~100% W_{peak}) reported less positive in-task to affect during HIIT and the continuous vigorous-intensity session, as compared to the continuous moderate-intensity session (Jung et al., 2014). Critically, despite lower in-task affect during HIIT, participants' intention to engage in HIIT was *not* different compared to exercising at continuous moderate-intensity (Jung et al., 2014). Examination of free-living exercise adherence 1-month (Jung, Bourne et al., 2015) and 6 months (Locke et al., 2018) after low-active adults with prediabetes were randomized to complete 10 exercise sessions of HIIT or moderate-intensity continuous training (MICT) demonstrated greater minutes of MVPA in the HIIT condition. Similarly, studies outside the laboratory, that examined young adults' affective responses post HIIT workouts in a university setting indicate that the students had high-perceived satisfaction, enjoyment, perceived benefit in engaging in HIIT, and reported high intentions to plan HIIT in the future (Eather et al., 2019). Importantly HIIT also translates into cardiorespiratory fitness gains and improvements in body composition, including Body Mass Index, body fat and waist circumference (Costigan et al., 2015). Other studies, on the other hand, that reporting on free-living adherence to unsupervised HIIT have demonstrated a sizable decline in adherence to HIIT post-intervention (Roy et al., 2018). This disparate evidence highlights the need for more research in the area of HIIT and its effects on free-living physical activity adherence.

Altogether, two gaps remain that question whether the previous recommendation to promote moderate-intensity exercise over higher-intensity exercise based on affective responses is appropriate. First, the evidence on the relationship between in-task affect and adherence comes from non-experimental study designs. As noted by Jung, Little et al. (2015) there is a need for experimental studies and use of objective measures of physical activity to examine the in-task affect and physical adherence relationship. Second, an experimental study design needs to combine in-task affect, HIIT and MICT, and objectively assess physical activity to make conclusions about the relationship between affective responses,

different exercise modalities, and physical activity adherence. The purpose of this randomized pilot study is to examine whether in-task affect predicts changes in objectively measured moderate-vigorous physical activity (MVPA) from baseline to one- and six-months post-intervention in individuals prescribed to engage in HIIT or MICT in their own time, unsupervised, over 6 months following a brief intervention.

Methods

Participants

Adults between the ages of 30 to 65 years old were recruited through community posters, online forums, and word of mouth. Eligibility criteria included 1) engaging in ≤ 2 aerobic bouts (~30 min) of moderate-intensity exercise sessions per week over the past 6 months, and 2) having prediabetes based on: a) a physician diagnosis; b) HbA1c values between 5.7% and 6.4% (American Diabetes Association, 2012) assessed using a clinically validated point-of-care monitor (HbA1c Now, Bayer Inc., ON, Canada); c) a score of moderate/high (> 21) on the Canadian Diabetes RISK Questionnaire (CanRISK), which is a risk assessment tool for prediabetes and type 2 diabetes (Kaczorowski et al., 2009); and/or d) fasting blood glucose of 5.6–6.9 mmol/L. Exclusion criteria included: a type 2 diabetes diagnosis, taking glucose-lowering medications, uncontrolled hypertension (blood pressure > 160/90), history of heart disease, previous myocardial infarction, or stroke, and any contraindications to exercise. All participants completed the Canadian Society for Exercise Physiology (CSEP) Physical Activity Readiness Questionnaire-Plus (PAR-Q+) and were cleared for participation in the vigorous activity by a CSEP Certified Exercise Physiologist® prior to entering the study. All participants who met the eligibility criteria provided written informed consent and were enrolled in the study.

Experimental design and procedures

The study was cleared by the University of British Columbia Clinical Research Ethics Board (CREB) in accordance with the *Declaration of Helsinki*. A detailed description of the intervention protocol has been reported elsewhere (Jung, Bourne et al., 2015). To summarize, eligible participants were randomly assigned to either HIIT or MICT conditions and received 10 exercise sessions performed over a two-week period. Seven of these sessions were supervised; three were self-managed at home (sessions 4, 7, and 9). Participants had choice in the exercise modality (e.g., inside or outside walking, elliptical, bike). The exercise prescriptions were progressive and matched for external work. The HIIT condition progressed gradually from 4 X 1 min to 10 X 1-min exercise sessions over the two-week period. The MICT condition progressed from 20 minutes to 50 minutes per session over the 10 sessions. For the three self-managed sessions, the HIIT condition was prescribed vigorous exercise requiring 75 minutes of time commitment per week (~90% HRpeak), and the MICT condition was prescribed 150 minutes of moderate activity per week (~65% HRpeak).

In addition to the exercise sessions, to promote long-term physical activity engagement, a brief 10-session counseling intervention (~10 min per session, for a total of 70 minutes of counseling time) was integrated that was based on social cognitive theory (Bandura, 1986). Namely, the purposes of the brief counseling intervention were to: (1) manage the physiological and affective expectations associated with the exercise sessions, (2) enhance confidence and ability to perform the exercise sessions (task self-efficacy), and (3) enhance confidence and ability to self-manage exercise (self-regulatory efficacy). Additional behavior change strategies targeted included outcome expectations, goal-setting, and relapse prevention. Both HIIT and MICT conditions received the same counseling intervention. Participants completed measures at baseline and at one- and six-months post-intervention. Graduate students in the Diabetes Prevention Research Group's laboratory supervised all sessions.

Measures

Objectively measured physical activity

Moderate Vigorous Physical Activity (MVPA) was measured objectively using the Actigraph GT1M (Actigraph™, LCC, Fort Walton Beach FL, USA). The GT1M is a dual-axis motion sensor, recording vertical and horizontal accelerations to determine physical activity intensity. Data were collected in 5-s epoch lengths. Epochs were summed to provide counts per minute. Valid wear time was ascertained using parameters set by (Choi et al., 2011). Participants were required to have at least three valid days of wear to be included in the analyses. The intensity cut-points categorized as: moderate (≥ 1,952 counts/min), vigorous (≥ 5,725 counts/min), and moderate-to-vigorous physical activity (MVPA; sum of moderate and vigorous) during wear time on valid days (Freedson et al., 1998). In addition, *purposeful exercise* was operationalized as minutes spent in MVPA in bouts of at least 10 minutes (MVPA10+), which was based on the physical activity guidelines recommending that physical activity needs to be accumulated in bouts of ≥ 10 minutes (Freedson et al., 1998). MVPA10+ is a measure of purposeful exercise (Glazer et al., 2013) and therefore an appropriate measure of

exercise adherence. In addition to MVPA10+, total time spent in MVPA was also analyzed at baseline at follow-up. To obtain total MVPA, the average physical activity counts for all valid wear days was calculated and multiplied by seven to provide the weekly estimate of total MVPA. Baseline MVPA were obtained at one-week prior to starting the intervention (baseline), at one- and six-months post-intervention (follow-up measures).

Self-report measures

In-task affect

The one item Feeling Scale (FS; Hardy & Rejeski, 1989) was used to measure general affective responses of pleasure and displeasure. The following instructions were provided to participants: "Some individuals find exercise pleasurable, whereas others find it to be unpleasant. Additionally, feelings may fluctuate across time. That is, one might feel good and bad a number of times during exercise. When asked please tell me how you feel at that current moment using the scale below." The feeling scale is scored on an 11-point bipolar scale ranging from −5 to +5. Seven anchors are provided ranging from, "Very Good" (+5) to "Very Bad" (−5). In the MICT condition, in-task affect was assessed at ~20%, ~50%, ~75%, and ~85% of exercise the exercise duration, completed during all seven supervised training sessions. For individuals in the HIIT condition, FS was measured in the middle of the 1-min intervals at~20%, ~50%, ~75%, and ~85% percent of exercise duration. In this study, in-task affect on the last day (Day-10) was averaged for both the MICT and HIIT sessions to examine whether average (dis)pleasure predicts long-term physical activity behavior.

Statistical analyses

Demographic differences between the MICT and HIIT conditions were analyzed with *t*-tests using SPSS version 22.0 (IBM Corp., 2013). The descriptive data and primary statistical analyses were conducted using Mplus 7.4 (Muthén & Muthén, 2014) with robust maximum likelihood estimator (MLR). MLR estimates parameters based on the available data as well as expected estimates between the observed and the missing data (Schlomer et al., 2010) and are suitable for smaller samples (Von Hippel, 2016). Analyses included all available data from the participants.

A multi-group repeated measures analysis was used for the primary analyses to determine whether average in-task affect during the last MICT and HIIT exercise session (Day-10) predicts changes in physical activity (MVPA10+ and MVPA-Total) at 1- and 6-months post-intervention relative to baseline between the MICT and HIIT conditions. Two dummy variables were created; the first, took the value of 1 for the 1-month post-intervention physical activity score, and otherwise 0; the second, was coded as 1 to indicate the 6-month post-intervention score, and otherwise 0. We first examined whether changes in physical activity (1) from pre-intervention to 1-month, and (2) from pre-intervention to 6-months post-intervention differed between the HIIT and the MICT conditions. Next, we examined whether the average in-task affect during the last exercise session (Day-10) predicted changes in physical activity from pre-intervention to 1- and 6-months post-intervention, respectively, by entering the two interactions between affect and the dummy variables, and lastly whether this effect of the average in-task affect on physical activity changes differed between the two conditions. To facilitate the interpretation of the interaction terms, the average in-task affect was centered using the mean of both experimental conditions. Significant interactions were probed for in-task affect scores that were ± 1 SD from the mean of both experimental conditions.

The rescaled −2 log-likelihood difference test, which is distributed as chi-squared with degrees of freedom equal to the rescaled difference in the number of parameters between models (Sattora & Bentler, 2010), was used to examine differences between the HIIT and the MICT conditions in (1) change in physical activity from (a) pre-intervention to 1-month post-intervention and (b) from pre-intervention to 6-months post-intervention and (2) the effect of average in-task affect during the last exercise session (Day-10) on change in physical activity from pre-intervention to 1- and 6-months post-intervention, respectively. Condition differences were examined by comparing the fit of a model in which an estimate (e.g., change from pre-intervention to 1- month post-intervention) was permitted to differ between conditions with the fit of a model in which the estimate was restricted to be equal in both conditions. A non-significant chi-square test value at $\alpha = .05$ indicated no condition difference in the estimate examined. The strengths of the effects are evaluated using the unstandardized coefficients, representing the change in physical activity relative to a unit increase/decrease in in-task affect.

Results

Thirty-two low-active adults living with prediabetes were randomized to the 2-week exercise intervention: $n = 15$ in the HIIT condition and $n = 17$ in the MICT. Thirty percent and 45% of the accelerometer exercise data were missing due to drop out or device malfunctioning for the 1-month

and 6-month follow-ups, respectively. Reasons for dropout included injury not related to study participation, diagnosis of depression, change of medication, or reasons not provided, refer to Jung, Bourne et al. (2015) for a detailed outline and number of dropouts. Two more people completed the 1-month follow-up but did not accumulate a valid number of wear days or had malfunctions with the accelerometer. There was no difference between the completers and the non-completers (at 1- and 6-months) on age, sex, BMI, and hemoglobin A1c levels. The 32 adults were mostly females (84.4%) at risk for type 2 diabetes with an average age 51 ± 9.91 years (min-max: 30 to 64 yrs). MVPA10+ (accumulated in 10-min bouts) at baseline for both groups was 25.59 ± 39.53 min, and 1- and 6-month follow up was 74.45 ± 78.92 min and 57.67 ± 70.81, respectively. For MVPA (total) baseline, 1-month, and 6-months activity in minutes was 280.83 ± 116.31, 313.47 ± 88.31, and 290.76 ± 122.73, respectively.

Manipulation checks

Peak heart rate

HR_{peak} was significantly higher in the HIIT than MICT condition across all seven exercise days (*P*-values<.001).

In-task affect between the conditions

On the last training day, participants in the HIIT condition reported that in-task affect was less pleasant (1.12 ± 1.42) compared to the MICT condition (2.74 ± 1.10), $P < .0001$. Similarly, participants in the HIIT condition, relative to participants in the MICT condition, reported a less pleasant in-task affect on five of the other six exercise intervention days (*p*-values range < .001 to .046). The participants in the HIIT condition relative to the MICT condition reported less pleasant affect on day five of the exercise intervention; however, this difference did not reach conventional levels for statistical significance (Refer to Table 1 for the in-task affect means and ±SD for both conditions).

Primary analyses: In-task affect predicts changes in physical activity at 1 and 6 months post-intervention

Refer to Table 2 for the correlations among the physical activity outcomes and average in-task affect at the last day of the exercise intervention (Day-10). Table 3 includes the unstandardized regression coefficients and statistical significance tests for the within- and between-condition effects of average in-task affect predicting change in physical activity from pre-intervention to 1- and 6-months post-intervention. Figure 1 provides a visual representation of the interaction effects; the effect of affect on changes in MVPA-10+ for HIIT and MICT.

Table 1. In-task affect means (*SD*) for the HIIT ($n = 15$) and MICT ($n = 17$) conditions for the seven supervised exercise sessions and the significance testing: unstandardized regression coefficients and 95% confidence intervals.

	HIIT		MICT			
Variable	Mean	SD	Mean	SD	β(SE)	95% CIs
FS Day 1	1.95	1.32	2.78	0.98	−0.83 (0.42)*	−1.64, −0.02
FS Day 2	1.10	1.36	2.93	1.29	−1.83 (0.47)**	−2.75, −0.91
FS Day 3	1.21	1.70	2.84	1.09	−1.63 (0.51)**	−2.64, −0.62
FS Day 5	1.43	1.92	2.27	1.41	−0.84 (0.62)	−2.06, 0.38
FS Day 6	1.33	1.59	2.65	1.13	−1.31 (0.49)*	−2.28, −0.35
FS Day 8	1.58	1.44	2.74	1.36	−1.15 (0.50)*	−2.13, −0.18
FS Day 10	1.12	1.42	2.74	1.10	−1.62 (0.45)***	−2.51, −0.73

*$p < .05$; ** $p < .01$; ***$p < .001$; FS = Feeling Scale (in-task affect); HIIT = High-Intensity Interval Training; MICT = Moderate-Intensity Continuous Training; HIIT = 1 and MICT = 0 (Dummy coded); β = unstandardized beta coefficients; SE = standard errors.

MVPA-Total

Baseline scores for MVPA-Total were not different between HIIT and MICT, and no group difference from pre-intervention to 1- and 6-months post-intervention. Subsequently, in-task affect was included in the model and the two interactions between in-task affect and the dummy variables. Average in-task affect in the model was unrelated to changes in physical activity from baseline to 1-month and 6-months for MICT and HIIT (see Table 3). No condition differences were observed in the extent to which average in-task affect at Day-10 predicted changes in total physical activity across time.

MVPA 10+

Baseline scores for MVPA 10+ were not significantly different between the conditions. Similar increases in MVPA 10+ were reported in both conditions from baseline to 1- and 6-months post-intervention (all *P*-values < .001). Subsequently, in-task affect was included in the model and the two interactions between in-task affect and the dummy variables. In-task affect was not related to changes in physical activity from pre-intervention to 1-month post-intervention in both conditions. However, in-task affect was negatively related to the extent of change in physical activity from pre-intervention to

Table 2. Correlations among the physical activity outcomes and in-task affect ($N = 32$).

Variable	1	2	3	4	5	6	7
1. FS Day 10							
2. B0: MVPA-Total	.27						
3. F1: MVPA-Total	−.18	.50***					
4. F6: MVPA-Total	.18	.59***	.23				
5. B0: MVPA 10+	.07*	.51***	.45*	.53***			
6. F1: MVPA 10+	−.13	.17	.65***	.40**	.62**		
7. F6: MVPA 10+	−.14	.28*	.24	.68***	.52***	0.29	

*$p < .05$; ***$p < .001$; FS Day 10 = Feeling Scale (in-task affect) taken on the last day of the exercise intervention; B0 = Baseline; F1 = 1-month follow up; F6 = 6-month follow up; MVPA10+ = Moderate Vigorous Physical Activity accumulated in bouts of ≥ 10 minutes; MVPA-Total = Total weekly minutes of Moderate Vigorous Physical Activity.

Table 3. Within- and between-condition effects of in-task affect predicting change in physical activity from pre-intervention to 1 and 6 months post-intervention.

	MVPA-Total			MVPA 10+		
Effects	β[a]	*SE*	95%CIs	β	*SE*	95%CIs
MICT						
Affect*Time 1-m	−12.80	21.71	−55.35, 29.76	−5.58	15.76	−36.46, 25.30
Affect*Time 6-m	−33.67	29.83	−92.12, 24.79	−38.60*	15.68	−69.34, −7.86
HIIT						
Affect*Time 1-m	−29.68	20.03	−68.93, 9.58	0.20	8.45	−16.37, 16.77
Affect*Time 6-m	9.70	28.12	−45.42, 64.82	2.91	8.26	−13.28, 19.11
Effects		χ^2 (*df*)			χ^2 (*df*)	
Baseline		0.65 (1)			1.69 (1)	
Change 1: Baseline—1 month post intervention		0.25 (1)			0.46 (1)	
Change 2: Baseline—6 month post intervention		.15 (1)			1.04 (1)	
Change 1 = Change 2		.51 (1)			0 (1)	
Affect → Baseline		1.02 (1)			1.44 (1)	
Affect*Change 1		0.32 (1)			.23 (1)	
Affect*Change 2		1.19 (1)			5.01 (1)	

[a]Unstandardized regression coefficients; [b]Standard Errors; *$P < .05$.

Analyses were based on 78 physical activity observations from 32 participants; MVPA-Total = total moderate-vigorous physical activity in minutes per week; MVPA 10+ = moderate-vigorous physical activity accumulate in bouts of ≥ 10 minutes per week; MICT = moderate intensity continuous training; HIIT = high-intensity interval training; 95%CIs: 95% Lower–Upper Confidence Intervals.

6-months post-intervention only for the MICT condition but not the HIIT condition. Physical activity increased for participants who reported low in-task affect, 103.91, $SE = 29.84$, $z = 3.48$, $p < .001$, but it did not change for those participants who reported high in-task affect, −13.52, $SE = 23.26$, $z = -.58$, $p = .561$ (refer to Figure 1).

Post-hoc power analyses

We conducted posthoc power analysis using Monte Carlo simulations in Mplus. This analysis reveals the extent of power present in this study to examine the research questions. The assumption tested with the posthoc power analysis is the following: if the model-estimated parameter values represent true population values, re-estimating the model using a set of randomly drawn samples of the same size from this population should yield significant values for the parameters of interest in a large proportion of these samples. We re-estimated the models using a set of 10,000 randomly drawn samples of 32 participants who provided 43 and 35 observations across the three measurement points in the MICT and HIIT conditions, respectively. The Monte Carlo simulations revealed that power to investigate the influence of in-task affect on change in physical activity over time across both conditions was low relative to a benchmark of .80 (considered as adequate power). For example, a value of .05 in the model examining change suggested that we would find a significant effect of in-task affect on change in only 5% of the randomly drawn samples. Increasing conditions' size to 50, 100, and 100 did not affect power (i.e., power remained low regardless of the sample size) suggesting that the null results reported in the present analyses are not due to small sample size.

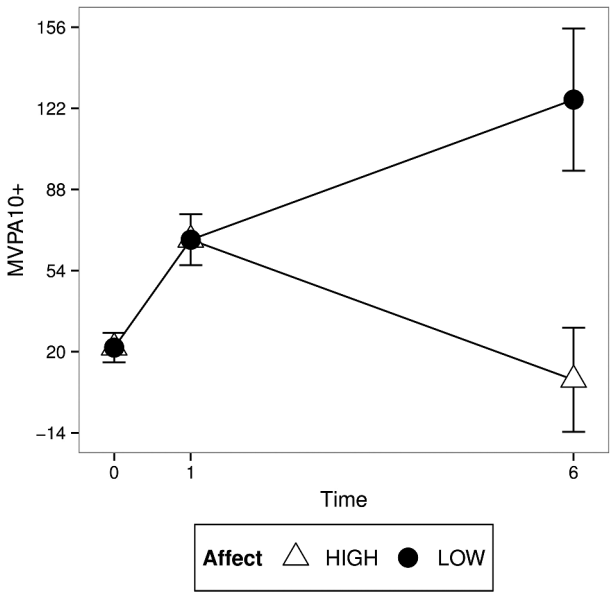


Figure 1. The interaction effects of the effect of low and high affect on changes in physical activity at 1- and 6-months (MVPA10+).

Discussion

The primary purpose of this analysis was to examine whether in-task affect during moderate intensity continuous training (MICT) or high intensity interval training (HIIT) predicts changes in total amount of moderate-vigorous physical activity (MVPA-Total) and purposeful activity MVPA+10 (≥ 10 minutes) from baseline to one- and six-months post-intervention. The participants were low-active adults with physician-diagnosed prediabetes

who were randomized to a two-week exercise intervention to receive either MICT or HIIT. At baseline, participants averaged less than 30 minutes of moderate-to-vigorous purposeful exercise per week, which fails to meet the minimum recommended amount for 150 minutes per week (Garber et al., 2011).

In summary, the average affective responses throughout the seven supervised sessions for the HIIT condition reflected "fairly good" (or FS = 1.1 average score) and for the MICT condition "good" (or FS = 2.7 average score). Of note is that the heart rate responses in the HIIT condition were significantly higher compared to the MICT, yet in-task affect was within a pleasurable range at all times. In relation to how these affective responses compare to the literature, it is difficult to make meaningful comparisons because in-task affective responses have been shown to differ based on the population characteristics, including gender, level of activity, or the samples' tolerance to exercise intensity (Bradley et al., 2019; Frazão et al., 2016; Schmitz et al., 2020). In this study, the sample was predominantly women (mean age 51 years) who at baseline did not meet the government recommended 150 min/week of physical activity, and their average in-task affective response was "fairly good." This affective response is above "0" or "Neutral," which is also in line with the findings by Frazão et al. (2016) in their sample of younger inactive men (mean age 25 years) performing HIIT.

Concerning the primary purpose of this study, these pilot findings indicated that for both conditions, in-task affect did not predict the extent to which participants changed their MVPA-Total levels from baseline to one- and six-months; while a condition difference was found for in-task affect negatively predicting MVPA-10+ over time. Specifically, for participants in the MICT condition only, those who reported *lower* in-task affect on day 10 had higher increases in MVPA-10+ levels from baseline to six-months post-intervention. The participants in the MICT condition reporting higher in-task affect on day 10 did not have changes in MVPA-10+ levels from baseline to six-months post-intervention. For the HIIT condition, effect of in-task affect on day 10 on changing levels of MVPA-10+ was not found. In addition, no differences between the conditions were found for in-task affect predicting changes in MVPA-10+ from baseline to one-month post-intervention.

Based on theoretical and some empirical evidence, these findings were surprising because of evidence that higher pleasurable responses during exercise are associated with long-term physical activity (Williams et al., 2008). This is in contradiction to the ACSM recommendations that propose moderate-intensity exercise as means to enhance exercise adherence because of its pleasurable association (Garber et al., 2011). There a number of potential reasons that may help explain the finding that lower in-task affect predicted higher physical activity over time in the MICT condition. First, individuals who reported lower in-task affect (but still pleasant affective responses) may have had more room to change their physical activity behavior over the 6 months (i.e., MVPA 10+) than those who already reported more pleasant in-task affect. These individuals may have found training more pleasant over time, and thus engaging in more MVPA 10+ as they progressed. Second, in-task affect was measured on the last day of the intervention and physical activity adherence was assessed at one and six-months post-intervention. This six-month period is lengthy and other factors may have accounted for the increased physical activity noted in this pilot study. Future research is needed that includes experimental designs with longitudinal follow-up data to assess not only changes in MVPA-10+ but also changes in affective responses during exercise overtime. This design would allow for analyses that would simultaneously address whether changes in affect during and post-intervention predict changes in subsequent MVPA-10+ over time.

In regards to MVPA-Total baseline scores were not different between the conditions, and MVPA-Total changed from baseline to one and six-months post-intervention in a similar way between the conditions. Lastly, there was no difference in the influence of in-task affect on total MVPA between the MICT and HIIT conditions. These preliminary findings refute claims that affective responses during a HIIT session would predict less physical activity engagement over time. The findings that in-task affect in the HIIT group was not predictive of PA behavior is in fact similar to Stork et al.'s (2018) findings that in-task affect was not predictive of subsequent number of HIIT or SIT (Sprint Interval Training) sessions performed 4-weeks later, instead in-task affect was only associated with subsequent number of MICT sessions performed.

Methodological considerations

The novel findings from this study contribute to the growing literature on affective responses during exercise and exercise adherence long term. To our knowledge, this is the first study to use an experimental design to manipulate in-task affect using MICT and HIIT supervised training protocols to predict long-term physical activity behavior. In addition, this is the first study to objectively assess physical activity adherence over a six-month period in relation to affective responses to exercise. This study has important practical implications because, it

demonstrates that lower pleasant in-task affect during HIIT does not predict long-term physical activity behavior when assessing physical activity in the real-world. Although the training of the participants was laboratory-based the long-term assessment of physical activity was based on participants' real-life physical activity behaviors, adding ecological validity to the study design. Notwithstanding these relevant contributions the present study had several limitations that need to be taken into consideration when interpreting the study findings.

First as mentioned above, in-task affect was not recorded during the six-month follow-up period of independent exercise. Future research is needed utilizing ecological monitoring devices to obtain information on in-task affect during unsupervised exercise and physical activity long term. The simultaneous examination of changes in physical activity and affective responses will allow for more accurate conclusions to be drawn for how in-task affect during exercise predicts physical activity behavior long term. Second, the sample size was small. This was a pilot study and it required a smaller sample size to test the primary study outcomes. Therefore, the small sample size needs to be considered when making conclusions about the findings, which need to be considered preliminary. Future research efforts are needed to replicate the study design using a larger sample size. Of note is that posthoc power analysis suggests that the non-significant findings between the two conditions on in-task affect and long-term physical activity behavior are not due to small sample size. The sample was mixed with female and male participants. Schmitz et al. (2020) recently suggested that female and male-specific HIIT protocols should be considered, because physiological sex differences could impact training performance. Future studies should be powered to examine possible sex differences in adaptations to HIIT, and the subsequent impact in physical activity in real-world settings.

What does this article add?

First, the preliminary results from this experimental study replicate previous findings that show that in-task affect during HIIT is less pleasant compared to MICT (e.g., Jung, Little et al., 2015). The second and key finding from this study is that we did not find support that less pleasant in-task affect during HIIT negatively predicts exercise behavior over time. The findings show that in-task affect during MICT negatively predicts moderate-vigorous exercise (in bouts of at least 10 minutes).

These preliminary results are relevant for two reasons. First, this study suggests that for low-active individuals HIIT may be a viable form of exercise, and not a deterrent to exercise as previously argued (e.g., Hardcastle et al., 2014). Second, these findings support the previously reported variability in affect during exercise (e.g., Astorino & Vella, 2018; Ekkekakis et al., 2005), and add evidence that this variability in in-task affective responses be predictive of lower physical activity over time. Future research is needed to understand the interindividual and intraindividual responses in in-task affect during MICT, their relationship to long-term physical activity behavior, and optimizing this form of exercise for long-term adherence. These findings are preliminary and this study suggests that larger trials are needed to confirm these findings and to continue to address the role of affective responses during exercise on physical activity adherence over time.

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