Do Preference and Tolerance for Exercise Intensity Moderate the Effect of Intensity Suggestions on Minutes of Weekly Exercise?

By:

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Thesis

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Abstract:

***Background*:** CDC recommendations for exercise intensity may be too strenuous, especially for obese or overweight adults. This is partially explained by a negative hedonic response many people have to physically intense exercise. People exercising at their chosen intensity, however, often have a more enjoyable and successful experience, increasing probability that their behavior will endure. Two dispositional traits, preference and tolerance levels for exercise intensity, are positively associated with affect during exercise and minutes of exercise. This suggests that high levels of these traits may prove to buffer the negative emotions accompanying intensity, allowing one to continue exercising. Low tolerance/preference individuals who are more susceptible to negative emotions, however, may need an alternative or flexible form of intensity instruction to suffice exercise requirements.

***Purpose*:** Tolerance and preference related to exercise will be assessed to determine whether they moderate the effect of exercising at a self-selected pace vs. imposed moderate intensity (mirroring CDC recommendations) on weekly minutes of exercise. It is hypothesized that people exhibiting high levels of these independent variables will not be influenced by different guidelines and should exhibit similar behavior across intensities. Conversely, those characterized as being low will demonstrate divergent behavior between intensity type. Specifically, we believe low tolerance individuals will engage in more weekly minute of exercise when the intensity is self-selected than at moderate intensity.

***Methods*:** This paper uses data from Brown University researcher David Williams (Williams et al., 2014) in which 59 overweight or obese participants from the Providence, RI area were enrolled into a between subjects, randomized controlled trial. Participants were randomized and instructed to exercise either at moderate intensity or at a self-selected pace. Data was collected over a 6 month period during which preference and tolerance were measured using a validated scale called the PRETIE-Q. PRETIE-Q data and randomization group were used as the IV in the moderation analysis, with weekly minutes of exercise employed as the DV.

***Results*:** Tolerance and preference failed to show a main effect on minutes of exercise and did not moderate the effect of randomization condition on minutes of exercise.

***Conclusions*:** The present study failed to demonstrate significant results to support hypotheses. There are several explanations for the findings: 1.) that preference and tolerance in reality do not serve to moderate the effect of condition on exercise, or 2.) some study level phenomenon obscured the effect. Further research with higher statistical power and different dependent variables to assess exercise behavior (calories burned, program adherence, etc.) are encouraged.

Background:

Physical inactivity is a burgeoning public health problem. Chronic sedentary behavior carries serious health implications, including increased risk for type 2 diabetes, certain cancers, hypertension, stroke, and cardiovascular disease - the leading cause of death in America (Lee et al., 2012). Lee and colleagues estimate that 30% of deaths from heart disease can be linked to physical inactivity and further states that between 6% to 10% of all deaths from non-communicable diseases can be linked to such behavior. With the additional economic burden and impact on quality of life, physical inactivity related morbidity has enacted a heavy cost to societies and their health systems (Lee et al., 2012). It can be stated unequivocally that public health measures must be taken to ameliorate these issues.

Generally accepted guidelines recommend that adults achieve at least 2.5 hours of moderate-intensity physical activity (e.g. brisk walk) or 1.25 hours of vigorous-intensity exercise such as jogging or running (Haskell et al., 2007; CDC, 2015). Unfortunately, it is estimated that only 31% of Americans get the recommended amount of exercise. Furthermore, 39% do not participate in *any* form of leisure-time exercise and 62% of Americans do not partake in any form of vigorous exercise (Barnes & Heyman, 2007; Pleis & Lethbridge-Cejku, 2006). To compound this, fewer people are engaging in occupational or travel related physical activity, further exacerbating the problem (Brownson et al., 2005; Knuth & Hallal, 2009).

One possible explanation for the lack of exercise may be the guidelines themselves, which encourage intensity levels that may be too strenuous for some people. Ekkekakis et al. (2007) notes that exercise is often prematurely terminated by participants because fatigue, muscle and joint pain, or exhaustion related to the intensity of aerobic work is perceived as too strenuous for them to continue. Intensity of exercise has been negatively associated with adherence to an exercise regimen, and positively associated with dropout rates (Perri et al., 2002; Cox et al., 2003).

In contrast, several studies have indicated that people who choose *their own* intensity of exercise are more likely begin and maintain a routine (Lind, Ekkekakis, & Vazou, 2008; Rose & Parfitt, 2007; Ekkekakis & Lind, 2006). Specifically, having control of intensity during exercise was associated with a more positive hedonic response and helped to foster greater feelings of autonomy (Lind, Ekkekakis, & Vazou, 2008). Moreover, individuals exercising at their preferred intensity have been found to be more adherent to exercise programs (Ekkekakis, 2009; King et al., 1990).

The recommendations issued by the CDC (CDC, 2015) and USDHHS (2008) may be particularly demanding for chronically overweight or obese individuals, for whom a brisk walk can be too physically strenuous. Exercise intensity and duration that exceeds one's self-perceived ability may produce negative affect (emotions), reduce rates of exercise, and encourage drop out (Perri et al., 2002; Cox et al., 2003). As approximately 70% of U.S adults are considered either overweight or obese (National Center for Health Statistics, 2013), addressing the overly-generalized exercise guidelines is necessary if meaningful steps are to be made in improving public health. Significant improvement in exercise rates may be possible by

conceding that overweight people may require a more tailored approach, so as to not discourage them from engaging in and continuing exercise behavior.

In accordance with this idea, Williams et al. (2014) demonstrated that overweight and obese adults instructed to exercise at their own pace showed a non-significant trend toward greater exercise-related energy expenditure as compared to adults told to exercise at a moderate intensity. Nested within the study's independent variables were two trait variables, tolerance and preference for exercise intensity, which have shown important associations with affect, and by association, amount of exercise.

Williams et al. (2014) operationally defines preference and tolerance as delineated in Ekkekakis et al. (2005). Preference constitutes "a predisposition to select a particular level of exercise intensity when given the opportunity" while tolerance is defined as "a trait that influences one's ability to continue exercising at an imposed level of intensity even when the activity becomes uncomfortable or unpleasant". Both these traits have demonstrated positive associations with affective responses to exercise at ventilatory threshold (the point of transition from aerobic to anaerobic metabolism when people begin experiencing exhaustion) and tolerance has been positively associated with affective responses above ventilatory threshold (Ekkekakis et al., 2005; Ekkekakis et al., 2007). These associations between these traits and affect have important implications on exercise behavior.

Functionally, it is theorized that people exhibiting high levels of tolerance may be more equipped to cognitively regulate how sensory information related to exercise is perceived at strenuous intensities (Tempest & Parfitt, 2016). In simple terms, while the physical sensation of exercise may be the same or similar between two people, the person with higher tolerance will process that sensory information in a way that elicits less negative affect compared to the person

with lower exercise tolerance. Because tolerance helps to buoy affect in the context of intense exercise, individuals demonstrating high levels of tolerance have been shown to persevere at higher intensities for longer periods of time before submitting to exhaustion (Lind, Ekkekakis, & Vazou, 2008; Ekkekakis & Lind, 2006). With respect to exercise science, high tolerance individuals have exercised longer above their individually determined respiratory compensation point (generally speaking, the boundary between difficult and extreme intensity exercise) despite no significant differences in participant's fitness levels (Tempest & Parfitt, 2016). Furthermore, this population is likely to engage in more minutes of exercise per session and has demonstrated greater adherence to exercise programs (Lind, Ekkekakis, & Vazou, 2008; Rose & Parfitt, 2007; Ekkekakis & Lind, 2006).

Conversely, people characterized as low in tolerance experience comparatively greater negative affect and demonstrate a more precipitous decline in affect during intense exercise relative to those with higher tolerance (Tempest & Parfitt, 2016). As such, under high intensity conditions, low tolerance individuals submit to volitional exhaustion more rapidly (Tempest & Parfitt, 2016). As there is great inter-individual variability in these traits, addressing tolerance and preference is crucial for delivering an actionable intervention with sustainable benefits. Schneider and Graham (2010) note it is crucial that people low in tolerance be treated with extra sensitivity when considering exercise prescriptions, as their negative experience with exercise increases their risk of becoming chronically sedentary. A high intensity exercise prescription, for instance, would likely be unpleasant and deter future exercise, whereas recommending a self-selected pace would be more enjoyable, tolerable and likely to yield sustainable behavior (Sheppard, 2008).

AIMS:

This paper intends to examine whether preference and tolerance for exercise intensity moderates the effect of intensity on minutes of exercise achieved. Given the findings of the previously stated literature, we hypothesize that people with a higher tolerance and preference for exercise intensity are unlikely to be impacted by instructions for exercising at a moderate intensity or at a self-selected pace. Regardless of the type of instruction, they are expected to exercise at a higher intensity and for longer. Alternatively, individuals with a low tolerance for intense exercise are more likely to demonstrate divergent behavior between intensity types. More specifically, people told to exercise at their self-determined pace will theoretically exercise more minutes per week, as exercise will be comparatively more enjoyable and achievable compared to a more intense instruction. As such, a gap in weekly exercise minutes is likely to appear between people exercising at their own pace versus those with an imposed intensity prescription among low exercise tolerant individuals. Due to the hypothesized discrepancy in minutes of exercise across instruction type for people exhibiting low tolerance and preference, and the relative stability of exercise behavior for groups characterized as being high in it, we believe that preference and tolerance will serve to moderate the effect of intensity guidelines on weekly minutes of exercise. Significant findings in support of this hypothesis may lend credence to the utility of personalized exercise prescriptions, particularly for individuals with low tolerance and preference, who may benefit from a self-selected intensity instruction.

Secondary aims of this analysis are to explore the association between preference/tolerance for exercise intensity and weekly minutes of exercise attained. Consistent with the literature, it is hypothesized that independent of exercise instruction, individuals with higher exercise tolerance and preference will engage in more minutes of exercise as compared to

those who do not. A significant main effect may indicate whether preference and/or tolerance have utility in predicting exercise behavior.

Finally, given the associations of both tolerance *and* preference with exercise outcomes, the two traits will be compared to determine if one is more predictive of exercise behavior than the other. While one's preference may influence the intensity of their exercise, the dependent variable of interest in this analysis is *minutes* of exercise achieved, for which it is expected that tolerance will be a better indicator. This is consistent with the previously stated findings which align high tolerance with greater minutes of exercise. Support of either may inform areas of focus for clinical use as well as for future research.

Methods:

Procedures:

This paper utilizes data from a study conducted by Brown university researcher, David Williams (Williams et al., 2014). The primary aim of this study was to test the efficacy of recommending self-selected vs. moderate intensity exercise for overweight and obese adults. The study employed a between subjects, randomized control trial design wherein participants in one arm were provided guidelines for healthy exercise without instructions for rate or intensity, meaning all workouts were self-paced. Participants in the other condition were instructed to exercise at a moderate intensity, which was operationalized as maintaining a heart rate between 64% - 76% of maximum heart rate during workouts (64%-76% of 220- participant age). Moderate intensity was employed as a comparison condition to self-selected pace as it parallels the guidelines issued by the CDC and other widely accessed references. Both groups were urged to participate in 30-60 minutes of exercise, five times per week. Participants used handheld electronic diaries to complete ecological momentary assessments (EMA). EMA entries included

duration of exercise, as well as minimum, maximum, and mean heart rate achieved during the workout (from heart rate monitors). Conditions were compared on minutes of exercise achieved per week, caloric expenditure, and intensity of exercise, which was operationalized as the percent of maximum heart rate achieved during a workout.

Participants:

59 people between the ages 18-65 from the Providence, RI area were recruited to participate in the study via radio, newspaper, internet, and brochures. The cohort was largely female (88%), with mean age of 47.71 years (SD = 11.06) and overweight or obese on average as determined by body mass index (BMI = 31.93 kg/m^2, SD = 3.99).

Measures:

Preference and tolerance as independent variables were assessed using a validated measure developed by Ekkekakis et al. (2005) called "The Preference for and Tolerance of the Intensity of Exercise Questionnaire" (abbreviated as "PRETIE-Q"). The PRETIE-Q presents 16 questions on a scale from 1 to 5, with 1 indicating "I totally disagree" and 5 representing "I totally agree". The measure is divided equally into questions assessing *tolerance* for high intensity exercise and *preference* for high intensity exercise. The variable was scored as stated in Ekkakakis et al. (2005) with 8 subscale items gauging tolerance for intense exercise (ex. "when exercising, I try to keep going even after I feel exhausted") and the remaining 8 assessing preference (ex. "Low intensity exercise is boring"). As delineated by Ekkekakis, eight subscale items were reverse coded due to the nature of their phrasing. For instance, responding with a 5 ("I totally agree") to the question "feeling tired during exercise is my signal to slow down or stop" would indicate low tolerance for intense exercise. With consideration of the reverse coded

items, potential scores could range from 16 if the participant answered each question with "I totally disagree", indicating dislike for intense exercise, to 80 if they selected "I totally agree" on each of the 16 questions.

Internal consistency of the PRETIE-Q was measured with alpha scores in order to gauge the reliability of the variable. In general, the 16 items were found to correlate well with each other, producing a Cronbach alpha score of .905, which is considered excellent. Individually, each item produced positive correlations with the total, ranging from .343 on item 16 ("the faster and harder the workout, the more pleasant I feel") to .766 on item 8 ("I always push through muscle soreness and fatigue when working out"). As the PRETIE-Q is validated, and removal of any subscale item would not drastically improve the consistency of the measure, the scale was not altered for statistical analyses. See Table 1. for full alpha scoring of the PRETIE-Q variable.

Statistical Analyses:

Group membership was dummy coded using moderate intensity as the reference group. The tests utilized for these analyses will be a series of regressions, the first of which regresses minutes of exercise on the PRETIE-Q to determine the main effect variable.

The central component of this analysis will be using a multiple-regression model with independent variables including PRETIE-Q scores and randomization condition to predict the dependent variable, minutes of exercise achieved per week. An interaction term between group membership and PRETIE-Q will then be added the model to assess moderation effects. The PRETIE-Q will be centered and divided into scores one standard deviation above and below the mean to examine the extremes of the variable.

Finally, the PRETIE-Q will be divided into preference and tolerance scores to measure which may ultimately be the better predictor of minutes of exercise achieved. Like the PRETIE-Q, these two variables will be centered and used to assess treatment conditions at high and low values. All analyses were conducted using SAS 9.4.

Results:

PRETIE-Q was normally distributed with a mean of 57.97 (SD= 11.14). Interestingly, a score of 57.97 (Mean of entire sample) indicates that the cohort, in general, tended to have a slightly positive opinion of intense exercise, which would seem to belie their baseline inactive behavior. The mean scores on the subscales of the PRETIE-Q were respectively 28.97 (SD = 5.21) for tolerance and 29.02 (SD = 6.91) for preference. Neither subscale was skewed or kurtotic.

Impact of Group Membership:

Participants were equally randomized into condition, although due to the uneven number of people in the cohort, the self-paced group contained one more member (n = 30) than the moderate intensity condition (n = 29).

On average, people in the study exercised 73.84 minutes per week, although with a sizeable standard deviation (64.58). The distribution of minutes exercised was somewhat kurtotic (1.40) and positively skewed, but only slightly (1.24). This is perhaps understandable as it is impossible to exercise fewer than zero minutes, while people can elect to exercise a nearly limitless amount.

The model regressing minutes per week on condition revealed no difference in total minutes of exercise achieved between self-paced and moderate-intensity groups (R^2 = .00009, F

(1, 57) = .05, p = .82). Therefore, instructions of exercise intensity failed to impact the time spent exercising per week.

Analysis of Preference and Tolerance:

Contrary to the hypothesis, the simple-linear regression predicting minutes of exercise from scores on the PRETIE-Q was not significant (R^2 = .0017, F (1, 56) = .10, p = .756). Of even greater surprise was the negative association (although non-significant) between the PRETIE-Q and the outcome (B = -.231, SE = .74, 95% CI [-1.71, 1.25]), signifying that as PRETIE-Q scores increased minutes of exercise decreased.

Condition membership and its interaction term with PRETIE-Q were added to the regression model. Again, the model was non-significant, R^2 = .004, F (3, 54) = .08, p = .97. PRETIE-Q coefficients were examined between the two conditions in context of the model. Participants in the moderate intensity condition were non-significantly associated with slightly fewer minutes of exercise per week, B = -.411, SE = 1.15, 95% CI [-2.72, 1.89], sr^2 = .002, p = .72. A similar non-significant trend appeared in the self-paced condition, B = -.097, SE = .996, 95% CI [-2.09, 1.90], sr^2 = .0002, p = .92. The interaction coefficient was non-significant, B = -.31, SE = 1.52, 95% CI [-3.36, 2.74], sr^2 = .0008, p = .837. Given the non-significant results, the upper and lower value ranges of the PRETIE-Q were not explored.

Predictive Ability of PRETIE-Q Subscales:

The final analysis examined which PRETIE-Q subscale was better able to predict minutes of exercise, independent of group membership. Tolerance and preference scores were entered into a regression model with group membership as a covariate and assessed for significance. The model as a whole was non-significant, R^2 =.009, F (3, 54) = .16, p = .92. As such, the regression

coefficients for tolerance, (B = .58, SE = 1.69, 95% CI [-2.81, 3.98], sr^2 = .002, p = .73) and preference (B = -.97, SE = 1.57, 95% CI [-4.11, 2.17], sr^2 = .007, p = .54) were likewise non-significant.

A regression model was created using preference, tolerance and their interaction term, as well as group assignment as a covariate. The model was non-significant again (R^2 = .047, F (4, 53) = .66, p = .62). The regression coefficient for tolerance was B = 5.07 (SE = 3.50, 95% CI -1.94, 12.09], sr^2 = .037, p = .15). The regression coefficient for preference was B = 5.14 (SE = 4.46, 95% CI [-3.81, 14.09], sr^2 = .024, p = .25). Despite positive trends presented for the individual model coefficients, the interaction term effectively reduced the magnitude of tolerance and preference regression coefficients (B = -.262, SE = .180, 95% CI [-.622, .098], sr^2 = .038, p = .150). As both subscales were non-significant, electing a stronger predictor is imprudent.

Discussion:

In summary, the stated hypotheses were not supported by statistical analyses. Subjective preference and perceived tolerance for exercise intensity were not associated with greater minutes of exercise achieved in this cohort. In fact, while the relationship was far from reaching significance, the trend exposed was negative, indicating that as these trait variables for exercise became higher, people engaged in slightly *fewer* minutes of exercise. Furthermore, preference and tolerance did not serve to moderate the effect of exercise instruction on minutes of exercise.

Dissecting the PRETIE-Q into its subscales showed a near interaction, as positive regression coefficients for tolerance and preference created a negative interaction coefficient, potentially suggesting a canceling of effects. With the disclaimer of non-significance in mind, this trend in general terms suggests that when controlling for each other at zero values, tolerance

and preference are non-significantly associated with greater minutes of exercise achieved per week. However, when adjusting for the inclusion of the other in the model, predicted minutes of exercise decreases. This is consistent with Ekkekakis et al. (2007), which demonstrated individual subscale associations with duration of exercise at ventilatory threshold that disappeared after inclusion of the other subscale in the regression model.

Two possibilities exist to explain the current findings: The first would conclude that tolerance and preference, in actuality, do not moderate the effect of exercise instruction on minutes spent exercising. As such, exercise prescriptions need not cater differently to people low or high in these traits. The alternative, however, is that some study level phenomenon occluded the moderation effect.

With respect to the latter option, myriad factors may have influenced the present findings. The current study employed a self-report method of data collection rather than direct measurement. According to a systematic review conducted by Prince et al. (2008), self-reported exercise is prone to both over *and* under-reporting compared to directly measured exercise. This poses several problems: that the accuracy of the data is potentially compromised, and that there is no reliable method of post-hoc statistical correction.

The study focus (exercise) also permits the possibility of a social desirability bias. For instance, the recorded tolerance and preference scores might reflect a more positive version of one's true exercise habits, in an attempt to look more favorable. This is a real possibility given that the overweight and low-active cohort indicated having an average PRETIE-Q score of 57.97 on a scale ranging from 16-80. In relatable terms, this means on average participants had a neutral to positive belief about themselves regarding behavior related to exercise intensity. If social desirability fails to describe the null findings, another explanation may be that, given

baseline inactivity, participants were simply *unaware* of their preferences and tolerance for exercise. Perhaps their responses reflect their preference or tolerance at a lighter weight. As the accuracy of this analysis is reliant on the precision of self-report, any of these factors may have shrouded the hypothesized moderation effect. Other limitations may include the small sample size and the lack of statistical power, the mostly female cohort (88%), and high rate of pre-randomization ineligibility.

Future analyses may also consider changing the dependent variable from minutes of exercise achieved, to caloric expenditure during exercise, or a related proxy variable. It is possible that, while minutes of exercise were equal, the pace at which it was conducted may have been disparate between groups. For instance, an individual in the moderate intensity group adhering to the guidelines imposed by group allocation, may run 60 minutes per week at 6 mph, resulting in 6 miles worth of exercise. Alternatively, someone in the self-paced group may engage in the same 60 minutes of exercise, yet unencumbered by suggestions of intensity, walk at an easier 3 mph clip, resulting in only 3 miles. This further analysis is paramount if one is to definitively dismiss tolerance and preference as being able to moderate the effect of intensity instruction on exercise habits.

Tables:

Table 1.		
Cronbach Coefficient Alpha of PRETIE-Q		
Variables	Alpha	
Standardized	0.900454	
Cronbach Coefficient Alpha with Deleted Variable		
	Standardized Variables	
Deleted Variable	Correlation with Total	Alpha
BS3EH1r	0.558383	0.900454
BS3EH3r	0.359955	0.90663
BS3EH5	0.527566	0.901468
BS3EH7	0.716461	0.895441
BS3EH9r	0.616183	0.898487
BS3EH11	0.602369	0.89897
BS3EH13r	0.370148	0.960642
BS3EH15	0.721139	0.895261
BS3EH2r	0.656776	0.89701
BS3EH4r	0.655539	0.89712
BS3EH6	0.519824	0.901882
BS3EH8r	0.770268	0.892971
BS3EH10	0.622534	0.898257
BS3EH12R	0.707429	0.895364
BS3EH14	0.57131	0.900147
BS3EH16	0.34561	0.907676

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This thesis by Michael Brian Brickley is accepted in its present form by the Department of Behavioral and Social Health Sciences as satisfying the thesis requirements for the degree of Master of Sciences.

Date _____ _____

David Williams, PhD, Advisor

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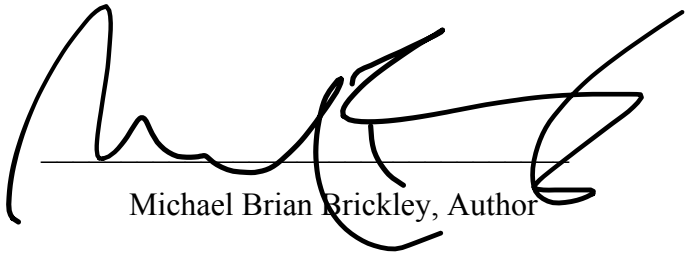
Date 4/1/18 

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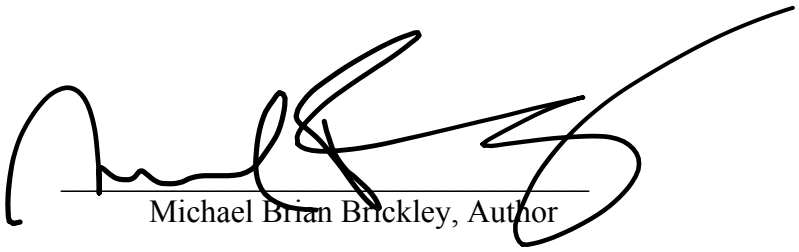
Date 4/1/18 

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