# DO SELF-REPORTED INDIVIDUAL DIFFERENCES IN PREFERENCE FOR AND TOLERANCE OF EXERCISE INTENSITY PREDICT CrossFit® WOD PERFORMANCE?

BY

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THESIS

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**ABSTRACT**

CrossFit® is an increasingly popular, wide-ranging strength and conditioning exercise program. Research has begun to shed light on the exercise intensity-affect-adherence relationship, but this kind of exercise is unique and has yet to be systematically studied. By examining individual difference characteristics (e.g., personality) of participants as well as their responses to single sessions of training, important information could be gained about the psychological makeup of the type of individual who does best in these high intensity group training settings. **PURPOSE:** Examine several individual difference factors, along with affective and enjoyment responses to an individual workout session. **METHODS:** Participants (*N* =39; 23 female; 32.2±7.9 yrs; BMI=24.34±3.38; *M*±*SD*) completed a number of measures of individual differences related to extraversion, including the Preference for and Tolerance of Intensity of Exercise Questionnaire (PRETIE-Q). On a separate day they performed a workout-of-the-day (WOD) consisting of 5 pull-ups, 10 box jumps, and 15 weighted ball overhead throws, which were done repeatedly for 12 min. Performance was the total number of repetitions completed. Measures of affect were completed pre and immediately post- WOD, along with measures of satisfaction and enjoyment. **RESULTS:** Average WOD performance was 197.95±39.3 repetitions, with satisfaction of 5.4±1.1 (somewhat satisfied) and enjoyment of 104.7±11.4 (range= 18-126). Affect changed from pre-to-post-WOD, with Energy (*d*= 1.44) and Tension (*d*= -0.79) increasing while Tiredness (*d*= 1.17) and Calmness (*d*= -1.01) decreased. Visual analog fatigue also increased (*d*= -1.34). Further, after accounting for age, sex, and BMI, Pref predicted unique variance in WOD performance ($\beta$= 0.48, $R^2\Delta$=21.4%, *P*= 0.003); after accounting for age, sex, and BMI, Tol predicted unique variance in WOD performance ($\beta$= 0.56, $R^2\Delta$=27.5%, *P*= 0.001). Those completing more repetitions also had greater satisfaction (*r*= 0.41, *P*= 0.005) and enjoyment (*r*= 0.43, *P*= 0.004) of the WOD. **CONCLUSION:** These findings extend previous research by

examining affective responses to high-intensity exercise along with providing evidence of individual difference factors that predict behavior in such types of exercise. Specifically, the findings suggest that individuals preferring and tolerating higher intensities of exercise push themselves more in such exercise settings.

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# CHAPTER 1

# INTRODUCTION

There are important implications in understanding the relationship between affective response to a specific type of exercise, and factors that influence that response. Specifically, the preference for and tolerance of high intensity exercise. Beyond more traditional factors (e.g., aerobic capacity, experience with exercise), individual difference characteristics like personality variables could have utility in understanding and explaining these affective changes. Indeed, this is one of the areas outlined by Ekkekakis, Hargreaves, and Parfitt (2013) as an important area for future research investigation. One such set of individual difference factors is the tolerance of and preference for high intensity exercise. For example, during an exercise tolerance test there is a great deal of variability in terms of when people choose to stop the test. Furthermore, this is often not consistent with what their physical capacity would allow. Although it is fairly straightforward to assume that psychological factors influence such variability (e.g., motivation), such effects are still relatively under-explored and remain not very well understood.

Exercise intensity tolerance has been defined as a trait that influences one's ability to continue to exercise at "levels of intensity associated with discomfort or displeasure" (p. 1194, Ekkekakis, Lind, Hall & Petruzzello, 2007). This also includes the ability to tolerate the amount of somatosensory stimuli associated with higher intensity exercise (Hall et al., 2014). An individual with higher tolerance could potentially perform better due to their ability to withstand these oppositional symptoms. One such attempt to examine this tolerance construct was done by Ekkekakis et al. (2007), who examined the associations of self-reported tolerance of exercise intensity and its role in exercise tolerance testing. The participants' self-reported tolerance levels were related to the duration they continued to exercise after they reached ventilatory threshold (i.e., the point at which significant declines in pleasure begin to occur during exercise). Such findings may be of interest to clinicians, personal trainers, coaches, and the like.

A preference for higher exercise intensity could also influence both affective responses as well as exercise behavior contribute to better performance by predisposing someone to more often exercise at a this higher level of intensity and thus routinely experience more training, or “practice”, at withstanding these greater levels of somatosensory stimuli.

These findings may be of interest to clinicians, personal trainers, coaches, and others. Exercise intensity preference and tolerance of intensity may have a larger effect on performance in exercise testing, the results from exercise training in a specific way, and performance in sporting or “exercise” type competitions. Thus, there is value in testing an athlete, a client, or a patient’s preference and tolerance before beginning a programmed regimen to predict the success of the program for them.

Over the past 10 years, worldwide surveys of identified fitness trends have been conducted by electronically surveying health and fitness professionals. For the four most recent surveys, the sample for these surveys has been between 18,474 and 29,630 individuals (Thompson, 2011, 2012, 2013, 2014, 2015). Of the top 20 fitness trends listed 2012, none would be considered high intensity exercise trends. For 2013, *body weight training* appeared on the list for first time, coming in at number 3 (Thompson, 2012). The list for 2014 revealed *high-intensity interval training* as the most popular fitness trend in its debut on the list (Thompson, 2013) with *body weight training* moving up to number 2. The trends for 2015 showed *body weight training* and *high-intensity interval training* trading positions, but remaining at numbers 1 and 2, respectively (Thompson, 2014). For the 2016 fitness trends survey, *body weight training* and *high-intensity interval training* each dropped one position on the list, behind only *wearable technology* (Thompson, 2015). Another interesting thing to note is that *functional fitness* was in the top 10 each of those years, ranked as somewhere between seventh and ninth, after first appearing on the survey in the number 4 position in 2007. All of these trends, coincidentally, correlate with the initial appearance of the CrossFit® games in 2010.

A current/popular version of high intensity exercise gaining worldwide popularity is the sport of CrossFit®. CrossFit® is a core strength and conditioning program created in 1995 by Greg Glassman. The goal of CrossFit® is to develop a broad, general, and inclusive fitness, the type of fitness designed to prepare one for a myriad of physical challenges they might encounter. Glassman chose to achieve this aim by incorporating constantly varied, high intensity, functional movements that include, but are not limited to, Olympic weightlifting, powerlifting, gymnastics, and metabolic conditioning. There are three standards a CrossFit® athlete is held to: (a) 10 physical skills, which include: cardiorespiratory endurance, stamina, strength, flexibility, power, speed, coordination, agility, balance, and accuracy; (b) the idea that fitness is about performing well at a broad range of physical tasks; and (c) the ability to perform well across the three metabolic pathways (ATP-Cr, glycolytic, and oxidative; CrossFit® training manual, accessed Jan 5, 2016).

A typical workout in CrossFit® is the "Workout of the Day", commonly referred to as the WOD. As stated in the CrossFit® standards, the WOD consists of a series of varied, functional movements, performed at a high intensity. The major aim of this study was to examine the relationship between preference for and tolerance of high intensity exercise and whether these individual factors predicted performance in a bout of high intensity exercise (i.e., WOD). It was hypothesized that greater preference for high intensity exercise and greater tolerance of high intensity exercise would be predictive of better WOD performance (i.e., greater number of repetitions). Furthermore, it was hypothesized that more traditional measures of extraversion would not predict WOD performance. Finally, it was hypothesized that preference and tolerance would be associated with self-reported enjoyment and satisfaction following the WOD.

# CHAPTER 2

# LITERATURE REVIEW

It is known that exercise elicits affective responses, sometimes very strong ones (Smith, Eston, Tempest, Norton & Parfitt, 2015). It has been proposed that affective responses are dependent on exercise intensity and related to the relationship between cognitive processes and physiological cues (Ekkekakis, 2003). Cognitive processes may take priority during lower intensity activities, while physiological cues take precedence at higher intensities (Ekkekakis, Hall & Petruzzello, 2005). Affective responses are mostly positive at lower-to-moderate intensities and negative at higher intensities (Hall, Ekkekakis, & Petruzzello, 2002).

Ventilatory threshold marks the physiological transition from aerobic to anaerobic metabolism. This has been shown to be the point where people may experience an increase in negative affect during the exercise. The literature has shown a pattern of positive affect response up to, and around ventilatory threshold, then a serious affective decline following ventilatory threshold. Variability in the intensity of these affective responses can be explained by an individual's preference for and tolerance of intensity of exercise. Ekkekakis et al. (2005) developed the Preference for and Tolerance of Intensity of Exercise Questionnaire (PRETIE-Q), which has been shown to predict the duration one will maintain exercising after ventilatory threshold has been reached, or at a level of high intensity, on a graded exercise test (Ekkekakis, Lind, Hall & Petruzzello, 2007).

Smith et al. (2015) examined the relationship between exercise intensity and affective responses in active older adults during a: (a) submaximal familiarization exercise test; (b) graded exercise test to volitional exhaustion; and (c) 20-minute bout of exercise at a self-selected intensity. Ventilatory threshold was determined during the graded exercise test. Rate of Perceived Exertion (RPE) was recorded throughout the graded exercise test, as well as utilization of the Feeling Scale for assessing affective response. In addition, the PRETIE-Q was completed to measure both the participants' preferred and tolerable intensities. During the graded exercise test, physiological responses (HR, $VO_2$) predictably increased in relation to intensity. Affective responses, while remaining positive, declined from the first minute 1 to the ventilatory threshold (VT). Once the VT was reached, RPE significantly increased and affective responses significantly decreased (i.e., became more negative) to the end of the test. During the self-selected exercise session, physiological responses (%$HR_{max,}$ %$VO_{2peak}$) significantly increased from 5 to 10 mins, and 10 to 15, but then stabilized from 15 and 20 min. Affect declined and RPE increased significantly at each time point, even though affect for the duration of the 20 minute session remained positive. Neither self-reported preference nor tolerance were significantly correlated with overall graded test duration, $VO_{2peak}$, or duration to exhaustion after VT was reached. However, there was a positive relationship with the preference (although not tolerance) scores and the physiological and affective variables across the *self-selected* exercise session. Specifically, after controlling for age, BMI, and fitness, preference accounted for an additional 29-39% of the variance in % $VO_{2peak}$ and 22-38% unique variance in %$VO_2$@VT across the 20 min exercise session (i.e., at 5, 10, 15 and 20 min) as well as 22-27% unique variance in self-selected speed.  These results can suggest that the preference for exercise intensity can influence one's choice in both initiating and maintaining exercise at a certain intensity as well as how that intensity is experienced. Data such as this has implications on exercise performance.

Ekkekakis, Lind, and Joens-Matre (2006) aimed to investigate the ability of the PRETIE-Q preference (not tolerance) scale to predict self-selection of exercise intensity. The study included 23 women who completed both the PRETIE-Q and two treadmill tests, one to volitional exhaustion (wherein VT was determined) and one at a self-selected pace. Consistent with their hypothesis, preference for exercise intensity was a significant predictor of the %$VO_2$@VT at minutes 15 and 20 of the 20-min self-selected session. This was shown to account for 17-18% of variance in self-selected intensity (expressed as %$VO_2$@VT). This supports the theory that the VT is subconsciously used as a reference point for the preferred intensity at which one exercises (due to the suggested negative affective response seen when exercising beyond the VT, the chosen level is the highest attainable without receiving negative feelings). These results have implications for the validity of the PRETIE-Q as a predictable measure of preference for exercise intensity and one's chosen exercise intensity level.

Ekkekakis et al. (2007) conducted another study aimed at investigating the role of self-reported tolerance of exercise intensity in exercise testing. Tolerance of greater exercise intensities may influence the ability to continue to exercise at intensities associated with discomfort or displeasure. An earlier study by Ekkekakis et al. (2005) showed that tolerance accounted for variability in the ratings of pleasure-displeasure during a 15-min treadmill run at 10% above the VT. As noted earlier, affect is seen to turn significantly negative once exercise intensity surpasses the VT. Ekkekakis et al. (2007) sought to evaluate whether or not tolerance scores were associated with the amount of time a participant continued on a treadmill test beyond the point of reaching their VT. Participants included 30 young, physically active individuals, and 27 middle-aged sedentary women. The PRETIE-Q was again used to assess preference and tolerance for each sample. On the day of testing, participants performed a graded exercise test, with the intensity alternatingly increased by 0.8 $km \cdot hr^{-1}$ or at a 1% grade, until the point of volitional exhaustion.

In the younger sample, the relationship between tolerance and duration after the VT did not persist once the $VO_{2max}$ had been taken into account. $VO_{2max}$ accounted for 18.9% of the variance in duration after the VT. When tolerance was introduced it explained an additional 6.5% in unique variance. More importantly, the relationship between tolerance and duration after the VT persisted after controlling for age, BMI, and frequency and duration of habitual physical activity. Overall, tolerance was predictive of the amount of time individuals persevered beyond the point of reaching their VT. It was suggested that tolerance might be related to the exercise test duration after the VT directly by influencing a person's perseverance against adverse body symptomatic reactions, and indirectly by predisposing an individual to exercise more and, thus, improve their fitness/$VO_{2max}$. In the middle-aged, sedentary sample the $VO_{2max}$ accounted for 40.8% of variance in test duration after surpassing the VT, but when tolerance was introduced it explained an additional 19% unique variance. Because these individuals were sedentary, the possibility of indirect influence of tolerance was eliminated. This suggests that tolerance can be associated with post-VT test duration independent of objective fitness level.

The majority of research examining the preference for and tolerance of exercise intensity has been related to cardiovascular fitness performance (graded exercise tests, $VO_{2max}$, $VO_{2peak}$). Hall, Petruzzello, Ekkekakis, Miller and Bixby (2014) examined the associations of scores on the PRETIE-Q with performance on fitness tests in two separate samples. The goal was to validate the PRETIE-Q test across a range of physical fitness tests.

The first study was a cross-sectional study of 516 college students who volunteered to participate in a free fitness testing program. After completing the PRETIE-Q, participants underwent an array of fitness testing consisting of: (a) three maximal voluntary contractions with their dominant hand on a hand grip dynamometer (muscular strength); (b) a 1-minute pushup test (upper body muscular endurance); (c) a 1-minute curl-up test (abdominal muscular endurance); (d) a 5-minute step test (cardiovascular endurance); (e) sit-and-reach test (flexibility); and (f) 3-site skinfold assessment (body composition). They also completed a questionnaire to assess self-reported physical activity over the previous 3 months. With the exception of the sit-and-reach test, preference and tolerance were significantly correlated with all fitness variables, body composition, and physical activity, explaining between 4-14% of the variance, even after controlling for age and BMI.

The second study utilized a pre-test (Week 1)/post-test (Week 6) design with 42 male firefighter recruits who, in addition to completing the PRETIE-Q, underwent a similar (although not identical) battery of fitness tests. The testing battery included: (a) 1-minute pushup test and (b) modified YMCA bench press (upper body muscular endurance; done on separate days); (c) 1-minute sit up test (abdominal muscular endurance); (d) 1.5 mile run (cardiovascular endurance); (e) sit-and-reach test (flexibility); and (f) 3-site skinfold assessment (body composition). They also completed a Perceived Fitness Index (PFI). The recruits were enrolled in a 6 week firefighter training program that included a physical training (PT) component. The PT was successful in improving fitness in all of the parameters assessed. Preference was related to performance in the 1.5 mile run tests at Week 1 (higher preference scores associated with faster time to complete the run, indicative of higher aerobic fitness), but not at Week 6. Tolerance was related to sit-ups, 1.5 mile-run, body composition, and the PFI at both Week 1 and at Week 6 along with push-ups (although only at Week 1). Importantly, this study showed that preference and tolerance scores were stable across the 6-week program (i.e., they did not change). This study was the first to demonstrate that preference and tolerance scores can account for some of the variance in performance across a variety of fitness tests.

As noted earlier, affective responses are associated with exercise and influenced by exercise intensity (Smith et al., 2015). It has been shown that affective responses are intensity dependent and related to the relationship between cognitive processes and physiological cues (Ekkakakis, 2003). Cognitive processes can have greater influence on affective responses during lower intensity activity whereas physiological cues become dominant at higher intensities (Ekkakakis et. al, 2005). Affective responses are mostly positive at lower intensities and negative at higher intensities (Hall et al., 2002). As noted earlier, high intensity interval training protocols/programs and functional fitness programs have been increasing in popularity (Thompson, 2015).

With respect to high intensity interval training [HIIT; sometimes also referred to as extreme conditioning programs, ECPs (Bergeron et al., 2013)], although shown to be extremely effective in producing positive physiological changes in various normal and clinical samples (see for example Gibala et al., 2006; Jelleyman et al., 2015), these protocols have been shown to result in decreased positive/increased negative feelings during and immediately after their completion. To date, there is little data on the enjoyment of such HIIT protocols.

Saanijoki et al. (2015) aimed to compare the acute affective responses to 6 exercise sessions [either moderate intensity training (MIT) or high intensity training (HIT)] performed over a 2-week period. Participants in the HIT group performed progressive HIT exercises consisting of 4 to 6 sets of 30 second maximal sprints on a cycle ergometer with 4 minutes of recovery between each sprint. For every other training session the number of sprints increased by one (Sessions 1, 2 involved 4 sprints; Sessions 3, 4 involved 5 sprints; Sessions 5, 6 involved 6 sprints). The MIT group performed 40 to 60 minutes continuous aerobic cycling at 60% of $VO_{2peak}$. Training duration, beginning with 40 minutes, increased 10 minutes every second session. During each training session, the participants rated their exertion levels using the Borg RPE 6-20 scale and well as their affect and arousal (pleasantness vs unpleasantness and calm vs. excited, respectively). These were administered after each sprint in the HIT group and every 10 minutes in the MIT group. Additionally, each group was given the Perceived Stress Questionnaire (PSQ, Levenstein et al., 1993), the Positive and Negative Affect Schedule PANAS, Watson, Clark & Tellegen, 1988), and several visual analog scales (VAS) assessing tension, irritation, pain, exhaustion, satisfaction, and motivation before each session and within 5 minutes of completing each session. Participants were encouraged to answer based on how they feel “at this point in time.” Each participant’s blood lactate level was also taken during their sessions.

As expected, blood lactate levels were significantly higher in the HIT group over the MIT group, indicating that the HIT group exercised closer to their lactate threshold than did the MIT group. The responses during exercise showed the same trend when comparing the HIT and MIT groups: as the number of bouts (HIT) or the duration increased (MIT), RPE and arousal progressively increased and valence became increasingly more unpleasant. All of these changes were greater in HIT: as the number of successive bouts increased (HIT), were more dramatically increased (RPE, arousal, degree of unpleasantness) compared to the increasing duration of the session (MIT). Affective responses before and after exercise showed that HIT resulted in more negative affect (e.g., greater stress, irritation, exhaustion, tension, pain) and less positive affect compared to the MIT group.

A study by Jung, Bourne and Little (2014) compared affect (before, during, after) and enjoyment and preference in response to independent sessions of HIT (20 minutes total, alternating between 1 min @ 100% $W_{peak}$, 1 min @ 20% $W_{peak}$), continuous moderate-intensity exercise (CMI; 40 minutes @ 40% $W_{peak}$), and continuous vigorous-intensity (CVI; 20 minutes @ 80% $W_{peak}$) cycle ergometer exercise. Relatively inactive participants performed all three conditions in a randomized, counter-balanced cross-over design. Affective valence (i.e., pleasure-displeasure) and perceived exertion were assessed at the beginning, middle, and near the end of the exercise session. Enjoyment was also assessed 20 minutes following the exercise using the Physical Activity Enjoyment Scale (PACES; Kendzierski & DiCarlo, 1991), modified by dropping one item from the original 18 items and changing the instruction to "Think about the exercise you did today and rate your enjoyment of it" as opposed to the original instructions where participants are asked to "Please rate how you feel AT THE MOMENT about the physical activity you have been doing." Jung et al. did not provide a rationale for changing these instructions. Two additional question related to enjoyment inquired about the enjoyment of the exercise just completed (20 min prior) and how much they would anticipate enjoying the same exercise if they were to do it again.

Perceived exertion was rated similarly for CVI and HIT and lower for CMI (as expected). All three exercise bouts showed a progressive decline in affective valence, but this decline was much more pronounced in HIT and CVI, with CVI being ~1 unit lower near the end of the exercise than HIT. Over 50% of the participants also disclosed that they would prefer to engage in HIT as opposed to MIT or CVI in the future. Following the exercise, HIT was rated as more enjoyable than CVI ($d = .64$) and comparable to CMI ($d = .32$). Finally, participants noted that they would prefer doing either HIT or CMI rather than CVI. Jung et al. concluded that HIT could be an alternative exercise modality, even for relatively inactive individuals.

In one of the few attempts at examining affective and enjoyment response to high intensity interval (HIIT) exercise protocols in overweight/obese inactive adults, Martinez, Kilpatrick, Salomon, Jung and Little (2015) examined four different protocols: (a) 20 min of continuous, heavy (HC) exercise (intensity between anaerobic threshold and maximal capacity); and three bouts of severe intensity (SI) exercise for (b) 24 min of 30-sec work:recovery (30-sec @ 60% of difference between anaerobic threshold and maximal capacity: 30-sec @ 10-20% maxamial capacity; SI-30); (c) 24 min of 60-sec work:recovery (SI-60); and (d) 24 min of 120-sec work:recovery (SI-120). For the three HIIT protocols, a total of 12 min of high intensity exercise was done along with 12 min of low intensity recovery. Participants were asked to rate their affect (using the Feeling Scale, FS) and enjoyment during the exercise bouts and enjoyment (PACES) following each bout. The FS response declined ~0.5 units in the SI-30 condition (i.e., it remained stable), ~1 unit during SI-60, ~2.6 units during SI-120, and ~2.4 units during HC. SI-120 and HC were very similar in terms of the affective responses. PACES score immediately following each bout were 91±13 (SI-30), 96±14 (SI-60), 81±24 (SI-120), and 83±21 (HC). Thus, the 30 and 60-sec interval protocols resulted in the least decline in affective valence and were the most enjoyable.

Tempest and Parfitt (2016) aimed to establish a relationship between cognitive and sensory processes in relation to tolerance of exercise and the affective response from exercise. Affective responses are proposed to be regulated in the brain, at least in part, by the prefrontal cortex (PFC). Reduced activation of lateralized regions of the PFC has been shown to be associated with a reduced ability to exert cognitive control to alleviate negative affective responses (Beauregard, 2007; Ochsner & Gross, 2008; Ochsner et al., 2004). Therefore, as noted before, during increased physiological demand (exercise) affective responses become increasingly more negative as intensity increases near or beyond the VT. Individuals are able to maintain PFC activation to override the negative affective responses that are driven by sensory input from the body (i.e. increased heart rate, lactic acid accumulation, etc). However, above the

VT the competition between PFC and subcortical regions (responsible for sensory input from the body) becomes increasingly challenging as does the ability to maintain PFC activation.

Tempest and Parfitt hypothesized that a potential factor that may impact this PFC activation, and thus the individual's level of cognitive control of affective responses, is dispositional traits. They conducted a study where participants completes the PRETIE-Q and only those with the highest and lowest tolerance measures ($N$=28; 14 in each group comprised of 7 males and 7 females) were selected. Participants completed an incremental cycling exercise test to exhaustion while cerebral hemodynamics were recorded using near infrared spectroscopy (NIRS) on either side of the scalp above the PFC. The end of the testing was determined by volitional cessation or inability to maintain the pedal cadence and $VO_{2peak}$ was recorded. Cerebral hemodynamic responses and affective responses were collected throughout the test.

The study provided three main findings: (a) asymmetrical PFC hemodynamics occurred during exercise at intensities above the VT; (b) although both groups showed a decline in affective valence, the Low-tolerance group reported a significantly greater decline in affective responses at intensities above VT; and (c) despite no differences in $VO_{2peak}$ between the two groups, individuals with high tolerance exercised longer (145±39 sec) above their respiratory compensation point (RCP; the point at which a physiological steady state cannot be maintained) than those with low tolerance (113±24 sec). At intensities below VT, no differences in PFC hemodynamics were seen between the high- and low-tolerance groups, and the affective responses were positive. At intensities from VT to RCP, there were no differences in blood flow to the right-PFC; however, the low-tolerance group showed greater blood flow in the left-PFC. Affective responses declined from VT to RCP, but were negative in the low-tolerance group while remaining positive in the high-tolerance group. Tempest and Parfitt speculated that, in the low-tolerance group, a larger hemodynamic response in the left PFC may have been required to maintain cognitive-control processes as the intensity of exercise started to become more challenging. In summary, it appeared that individuals with low-tolerance may utilize cognitive mechanisms subserved by the left PFC during exercise at intensities above VT. Those individuals with high tolerance do not appear to utilize the left PFC until intensities of exercise become much greater (above RCP). Tolerance potentially influences the relationship between cognitive and sensory processes that influence the regulation of affective responses.

Other personality factors have been shown to be related to affective response to exercise in addition to preference for and tolerance of exercise. Schneider and Graham (2009) hypothesized that, among adolescents, behavioral activation (BAS) and behavioral inhibition (BIS) systems would be associated with aerobic fitness, enjoyment of exercise (affect), and tolerance and persistence of a high-intensity exercise bout. They recruited 146 healthy adolescents to participate in a cardiovascular fitness test, body composition assessment, and two 30-min cycle ergometer exercise tasks at moderate and at hard intensities. The participants completed BIS/BAS questionnaires, enjoyment of exercise questionnaires (PACES), and preference and tolerance for high-intensity activity questionnaires (PRETIE-Q). The Feeling Scale and the AD-ACL were used to assess affect. RPE was using throughout testing to measure the individual’s level of perceived exertion.

BIS was negatively correlated with cardiovascular fitness and tolerance for high-intensity exercise, and adolescents with high BIS scores reported more negative FS responses to exercise at both moderate and hard intensities. BAS was positively correlated with enjoyment of exercise, and adolescents with high BAS scores reported having more positive FS and higher energetic arousal on the AD ACL in response to moderate-intensity exercise. The association between BAS and affect was weaker for the hard-intensity exercise task. This is the first study to examine the contribution of BIS/BAS to individual differences in affective response to exercise. These findings suggest that both the drive to avoid punishing stimuli (BIS) and the drive to approach rewarding stimuli (BAS) are related to the affective response to exercise. The BIS may be more strongly associated with fitness-related exercise behavior among adolescents than the BAS, whereas the BAS may play a relatively greater role in terms of individual exercise enjoyment.

It is apparent that personality factors related to extraversion could be predictive of exercise behavior as well as affective responses to exercise. Whereas traditional measures of extraversion do not always explain exercise behavior, the PRETIE-Q, with its subscales for Preference of exercise intensity and Tolerance for exercise intensity hold promise for explaining such behavior.

## CHAPTER 3

## METHODS

### Participants

Men and women were recruited for the study from a CrossFit® gym (i.e., box) in East Central Illinois. All were members of the box and were recruited via word of mouth and flyers posted at the box. They ranged in age from 21 to 52 years, with a final sample of 23 females and 16 males.

### Measures

Several measures were used to assess individual differences in this study. Specific information for each follows.

Preference for and Tolerance of Exercise Intensity (PRETIE-Q; Ekkekakis et al., 2005). To assess individual differences in the preference for and tolerance of exercise intensity, the PRETIE-Q (Ekkekakis et al., 2005) was used. It consists of two 8-item scales: (a) Preference for Exercise Intensity (e.g., "I would rather have a short, intense workout than a long, low-intensity workout") and (b) Tolerance of Exercise Intensity (e.g., "When exercising, I try to keep going even after I feel exhausted"). Each item is accompanied by a 5- point response scale, ranging from 1 ("I totally disagree") to 5 ("I totally agree"). In this study, Cronbach's alpha coefficient of internal consistency was 0.84 for the Preference scale and 0.80 for the Tolerance scale.

Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1964). Developed by one of the most prominent personality psychologists, the EPI is a 57-item measure of the two most prominent personality dimensions, namely extraversion-introversion and neuroticism-stability. Respondents use a yes-no response format to each of the items.

International Personality Item Pool (IPIP; Goldberg et al., 2006). The Big 5 personality factors [extraversion, emotional stability (tendency to experience negative feelings), conscientiousness, agreeableness (concerned with cooperation, social harmony) and intellect/imagination (traits such as imagination and insight)] were assessed using a 50-item version of the IPIP. Each factor was derived based on responses to 10 items using a 5-point Likert scale (1 = Very Inaccurate; 3 = Neither Inaccurate nor Accurate; 5 = Very Accurate).

Modified Zuckerman-Kuhlman Personality Questionnaire (Modified ZKPQ; Zuckerman, 2002). An alternative to the more traditional five-factor models, the original ZKPQ is a 99-item scale with personality factors referred to as Impulsive Sensation Seeking (ImpSS), Neuroticism-Anxiety (N-Anx), Aggression-Hostility (Agg-Host), Activity (Act), and Sociability (Sy). Responses are made to each item using a True or False response option.

Enjoyment. The Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991) was used in order to assess enjoyment following each condition. The PACES contains 18 bipolar statements that anchor the ends of a 7-point response scale where participants choose the number that most closely corresponds to the way they feel at the moment about the physical activity they have just been doing [e.g., “I enjoy it (1) .... I hate it (7)”; “I dislike it (1) …. I like it (7)”]. Scores on the PACES range from 18 to 126. Kendzierski and DeCarlo (1991) demonstrated that the PACES was valid and had acceptable internal consistencies in two separate studies (Cronbach’s alphas = 0.93 in both). PACES scores in the present study ranged from 89 to 123 (*M* =106.55) in the moderate intensity condition and 55 to 125 (*M* = 99.23) in the high intensity condition.

Satisfaction. Satisfaction with the workout was assessed with a 1-item measure ranging from 1 to 7 (1=not at all satisfied, 7=very satisfied). Participants completed the scale upon completion of the WOD.

Performance. Performance was also assessed for the WOD. This was determined by the total number of repetitions of the three exercises (5 pull-ups, 10 box jumps, 15 wall-balls) that were completed in the 12-minute time period for the WOD.

Affect. Affective responses were assessed in several ways. The Feeling Scale (FS; Hardy & Rejeski, 1989), in conjunction with the Felt Arousal Scale (FAS; Svebak & Murgatroyd, 1985), was used to measure affective valence following the dimensional approach for assessing affect (Ekkekakis & Petruzzello, 2002). The FS is an 11-point, single-item, bipolar measure of pleasure-displeasure ranging from ‘Very Good’ (+5) to ‘Very Bad’ (-5), with verbal anchors provided at zero (Neutral) and at all odd integers. The FS has been commonly used for the assessment of affective responses before and after, but especially during, exercise (Ekkekakis & Petruzzello, 1999). The FAS was used to measure perceived activation during the exercise bouts. The FAS is a 6-point, single-item measure, ranging from 1 (Low Arousal) to 6 (High Arousal). The FAS is strongly correlated with valid single-item measures used to assess activation. The Activation Deactivation Adjective Check List (AD ACL; Thayer, 1986) was also used for assessment of affect. The AD ACL is comprised of 20-items, with five items for each of four subscales: Energy, Tiredness, Calmness, and Tension. Each item is rated on a 4-point rating scale (definitely feel=4, feel slightly=3, cannot decide=2, definitely do not feel=1; Thayer, 1986). Four separate visual analog scales were also incorporated as a separate assessment of fatigue (VAS_Fatigue: No fatigue at all to fatigue as bad as can be; VAS-Tense: relaxed to tense; VAS-Calmness: jittery to calm; VAS-Nervous: nervous to at ease). Participants placed a vertical line along a 10 cm horizontal line anchored at the ends by the descriptors noted above. The distance from the left side of the 10 cm line to the vertical line is measured in millimeters and recorded as the score.

State Anxiety. The short form of the State Anxiety Inventory (SAI, Form Y-1; Spielberger, 1983) was used to measure anxiety. This is a 10-item measure of state anxiety suited for studies with repeated measures designs where the repeated assessments need to be made relatively quickly (Spielberger et al., 1983). It has been shown to be a valid and reliable measure of anxiety. As with the AD ACL, each item is rated on a 4-point rating scale (definitely feel=4, feel slightly=3, cannot decide=2, definitely do not feel=1) with the instructions to base the response on how “you feel right now”.

Perceived Exertion. Perceptions of effort were assessed using Borg’s 15-point Rating of Perceived Exertion (RPE; Borg, 1998) scale.  Participants are given instructions to pay attention to how hard the exercise work rate is, with their rating being a reflection of their total amount of exertion and fatigue, combining all sensations of physical stress, effort, and fatigue. They are not to be concerned with any single factor (e.g., leg pain, shortness of breath, exercise intensity), but should instead focus on the total, inner feeling of exertion. The scale uses a continuum that ranges from 6 (no exertion at all) to 20 (maximal exertion). Participants rated their effort during the WOD immediately following its completion.

**Procedure**

Participants engaged in 2 separate sessions. In the initial session, they completed an informed consent document approved by the University of Illinois Institutional Review Board and a battery of questionnaires including: a Health and Physical Activity History Inventory (basic demographic information), the Physical activity Readiness Questionnaire (PAR-Q; Thomas, Shepherd & Reading, 1982), the PRETIE-Q, the IPIP, and the Modified-ZKPQ.

On Day 2, participants arrived to the gym (i.e., the box) and began the session with 5 minutes of cardiovascular, multi-joint warm up exercises (e.g., jump squats, burpees, jump rope, etc.) to prepare them for mobilization (i.e., stretching). Following the warmup, participants engaged in 12 minutes of the following mobility exercises: 2 minutes each side of band-over-head (the participant wrapped a band over a pull up bar and grasped the band at full arms reach overhead and stepped back the same side leg to open the shoulder joint and stretch the latissimus dorsi); 2 minutes each side of hip extension (participant knelt on 1 knee and pressed that same hip forward to stretch the hip flexor muscles); and 2 minutes each side of lacrosse ball on shoulder (participants held a lacrosse ball against the wall with their shoulder and massaged the ball into the deltoid and pectoral muscles to create a myofascial release and increase flexibility and range of motion of the shoulder joint). During this mobilization time, researchers explained the questionnaire participants would be completing prior to and following the WOD. The packet consisted of a pre-WOD section of measures a post-WOD section of questionnaires including: Rating of Perceived Exertion, PACES, the Workout Satisfaction

Rating, their Workout Score (i.e., number of repetitions), and the time of day for the workout. Participants then completed the pre-WOD section during the mobilization period.

Following mobility, participants were briefed on the logistics of the WOD. The WOD consisted of a 12 minute AMRAP (as many rounds as possible) of 5 pull-ups, 10 box jumps [either a 24” (males) or 20” box (females)], and 15 wall-balls [20 pound ball (males) or 14 pound ball (females)], totaling 30 reps per round. In order for a pull-up to count for a repetition a participant’s hands needed to be gripping the bar in a prone position. A participant’s chin was required to break the plane of the pull-up bar. They could choose to do any variation of the pull-up (strict, kipping, or butterfly). A participant could also choose to scale the pull-up by using bands wrapped around the bar and their feet to assist in pulling themselves up. In order for a box jump to count for a repetition, the participant’s feet had to leave the ground at the same time, they needed to land on top of the box, and then they were required to stand fully upright so that their hips fully extended open before returning to the floor. They could either jump off the box or step down from the box as long as both feet left the floor at the same time on the next repetition. A participant could elect to scale this movement by lowering the box height. Finally, a wall-ball is a movement in which a participant holds a ball, squats with the ball, extends the squat and throws the ball at an intended target. Upon ball descent, participants begin the process again. In order for a wall-ball repetition to count, the participant’s hip crease needed to break the plane of parallel to the floor during the squat portion and the ball was required to hit at or above a 10-foot target for men and a 9-foot target for women. A participant could elect to scale this movement by lowering the weight of the ball, but the target heights remained the same.

The workout was scored by how many completed repetitions a participant completed. For example: A participant completes 5 full rounds of 5 pull-ups, 10 box jumps, and 15 wall balls and with 30 seconds left completes 5 pull-ups, and 2 box jumps. This participant would have completed then 5 + 7 reps and would write their score as 157 repetitions.

Following the briefing, participants gathered the necessary gear to complete the workout. Once everyone was ready, the clock gave a 10-second warning count down and the participants began when the 12-minute count down began. Immediately following the workout participants completed the post-WOD section of the questionnaire, including their score on the workout (i.e., number of repetitions), how satisfied they were with their scores, and the time of day they completed the workout.

# CHAPTER 4

## RESULTS

A total of 39 individuals (23 females; age=32.23 ± 7.8 yrs, height=171.2 ± 11.3 cm; weight=72.06 ± 14.8 kg) participated in the study. Descriptive information appears in Table 1. Participants self-reported their exercise frequency to be almost 5 $d \cdot wk^{-1}$ (4.8 ± 1.1), duration of their exercise sessions to be almost an hour in length (55.51 ± 13.6 min), and the average intensity of their workouts (using the Borg CR-10 scale; Borg, 1998) to be 6.25 ± 1.6. A multivariate analysis of the variables comparing males and females revealed an overall main effect for sex [Wilks' $\lambda$=0.427, $F(6, 32)=7.16$, $p< 0.001$, $\eta_p^2=0.57$]. Not unexpectedly, males were taller ($p=0.001$) and weighed more ($p< 0.001$), whereas females reported more frequent exercise ($p= 0.04$).

Table 1

Descriptive Information for the Sample

| | Male (*n*=16) | | Female (*n*=23) | | Total (*N*=39) | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Age | 33.06 | 7.4 | 31.65 | 8.2 | 32.23 | 7.9 |
| Height (cm)* | 178.26 | 13.6 | 166.27 | 5.7 | 171.2 | 11.3 |
| Weight (kg)* | 83.88 | 14.4 | 63.83 | 7.95 | 72.06 | 14.8 |
| Frequency ($d \cdot wk^{-1}$)* | 4.37 | 1.0 | 5.10 | 1.1 | 4.8 | 1.1 |
| Duration ($min \cdot session^{-1}$) | 58.43 | 14.8 | 53.48 | 12.74 | 55.51 | 13.66 |
| Intensity | 6.62 | 1.8 | 6.0 | 1.4 | 6.3 | 1.6 |

*Note:* *$p< 0.05$ difference between males and females. See text for specifics.

Consistent with the primary aim of the study, preference for and tolerance of high intensity exercise were examined for their relationships with self-reported exercise behaviors (e.g., frequency, duration, intensity) and, more importantly, whether these individual factors predicted performance in the WOD.

Preference for and tolerance of exercise intensity were correlated with average frequency of moderate-to-strenuous exercise for at least 30 min over the past 6 months, average weekly exercise frequency, average duration per session, average intensity, how long the participant had been involved with CrossFit®, and whether they engaged in CrossFit® competitions. Preference was significantly related only to average intensity ($r$= 0.41, $p$= 0.009), although there was also a tendency for higher Preference to be associated with average frequency of exercise for the past 6 months ($r$= 0.29, $p$= 0.057) and for average session duration ($r$= 0.27, $p$= 0.079). Tolerance significantly associated with average frequency over the past 6 months ($r$= 0.36, $p$= 0.017).

It was of interest to examine how the preference and tolerance scales compared to other commonly used measures for assessing personality. Specifically, correlations between preference and tolerance were examined with extraversion measures from the International Personality Item Pool (IPIP, Goldberg et al, 2006), the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, 2002), and the Eysenck Personality Questionnaire (EPQ, 1985). First, there were no significant relationships with the ZKPQ extraversion subscales (all $r_s$= 0.04-.24, $p_s$> 0.12). Preference was not related to the Eysenck measure of extraversion ($r$= 0.18), but Tolerance was ($r$= 0.38, $p$= .012). Likewise, with the extraversion measure from the IPIP there was no relationship with Preference ($r$= 0.15), but there was for Tolerance ($r$= 0.55, $p$< .001). Two of the three subscales comprising the IPIP Extraversion measure were significantly associated with Tolerance (*Excitement-Seeking*: $r$= 0.37, $p$= .014; *Activity Level*: $r$= 0.47, $p$= .001) and the third approached significance (*Assertiveness*: $r$= 0.28, $p$= .064). IPIP Conscientiousness was significantly related to Preference ($r$= 0.41, $p$= .006), while marginally related to Tolerance ($r$= 0.26, $p$= .086). Of the subscales making up Conscientiousness, Orderliness was significantly associated with Preference ($r$= 0.38, $p$= .012). Finally, it is worth noting that none of the Neuroticism measures were significantly related to either Preference or Tolerance (all $r_s$< -0.15, $p_s$> 0.34). It was hypothesized that greater preference for high intensity exercise and greater tolerance of high intensity exercise would be predictive of better WOD performance (i.e., greater number of repetitions). As an initial step, relationships between Preference, Tolerance, and more traditional measures of Extraversion with WOD performance were examined. Both Preference ($r$= 0.49, $p$= .002) and Tolerance ($r$= 0.43, $p$= .006) were significantly associated with WOD performance. Extraversion as measured from the EPQ was significantly associated with WOD performance ($r$= 0.38, $p$= .019). In spite of relationships between Preference-Tolerance and the extraversion measures from the IPIP, none of those measures were associated with WOD performance (all $r_s$= 0.06-.26, $p_s$> 0.11).

Summary data for performance on the WOD, satisfaction with that performance (1=not at all satisfied, 7=very satisfied), and enjoyment of the WOD are presented in Table 2, both overall as well as separately for males and females. There were no differences between males and females, although females tended to enjoy the workout slightly more than males. WOD performance was significantly associated with both Satisfaction ($r$= 0.41, $p$= .005) and Enjoyment ($r$= 0.43, $p$= .004).

Table 2

Workout of the Day (WOD) Performance, Satisfaction, and Enjoyment

| | Male (*n*=16) | | Female (*n*=23) | | Total (*N*=39) | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| WOD Performance (# of repetitions) | 195.2 | 43.8 | 199.9 | 36.7 | 197.95 | 39.3 |
| Perceived Exertion (RPE) | 16.4 | 1.6 | 15.96 | 2.0 | 16.2 | 1.8 |
| Satisfaction | 5.2 | 1.1 | 5.5 | 1.1 | 5.4 | 1.1 |
| Enjoyment (PACES) | 100.5 | 11.0 | 107.6 | 11.0 | 104.7 | 11.4 |

It was hypothesized that more traditional measures of extraversion would not predict WOD performance, whereas Preference and Tolerance would. Separate hierarchical regression analyses were conducted with Preference as the predictor of WOD performance in one analysis and Tolerance as the predictor variable in the other. In both analyses, age, sex, and BMI were entered into the regression equation before either Preference or Tolerance, respectively. After accounting for age, sex, and BMI ($R^2$=0.079, or about 8%), the addition of Preference accounted for an additional 21.4% of the variance in WOD performance [$\beta$= 0.477, $F_{change}$(1, 33)= 9.96, $p$= 0.003]. Using Tolerance to predict performance resulted in a total $R^2$ of 35.4% explained variance. After accounting for age, sex, and BMI ($R^2$=0.079, or about 8%), the addition of Tolerance accounted for an additional 27.5% of the variance in WOD performance [$\beta$= 0.561, $F_{change}$(1, 33)= 14.05, $p$= 0.001].

Running the same analyses but using IPIP Extraversion also explained 18.5% of the variance in WOD performance, accounting for an additional 10.6% of the variance in WOD performance [$\beta$= 0.379, $F_{change}$(1, 33)= 4.28, $p$= 0.046] after accounting for age, sex, and BMI. Using Extraversion from the EPI explained 20.2% of the variance in WOD performance, accounting for an additional 12.1% of the variance in WOD performance [$\beta$= 0.415, $F_{change}$(1, 32)= 4.85, $p$= 0.035] after accounting for age, sex, and BMI. Thus, while more “traditional“ measures of extraversion do explain performance in this high-intensity type of exercise, they account for less than half of the variance accounted for by the Preference and Tolerance measures. In fact, adding Preference to the regression after controlling for age, sex, BMI, and EPI-Extraversion still explains an additional 16.4% unique variance in WOD performance [$\beta$= 0.424, $F_{change}$(1, 31)= 7.99, $p$= 0.008]. Adding Preference after controlling for age, sex, BMI and IPIP-Extraversion explained an additional 18.4% unique variance in performance [$\beta$= 0.446, $F_{change}$(1, 32)= 8.89.320, $p$= 0.005]. . In fact, adding Tolerance to the regression after controlling for age, sex, BMI, and EPI-Extraversion still explains an additional 17.9% unique variance in WOD performance [$\beta$= 0.496, $F_{change}$(1, 31)= 8.98, $p$= 0.005]. Adding Tolerance after controlling for age, sex, BMI and IPIP-Extraversion explained an additional 17.6% unique variance in performance [$\beta$= 0.513, $F_{change}$(1, 32)= 8.80, $p$= 0.006]. Thus, while traditional measures of extraversion did predict unique variance in WOD performance, Preference and Tolerance explained a significant amount of unique variance beyond those measures, demonstrating that they are tapping into a different aspect of extraversion (i.e., interoceptive stimuli).

Tolerance also explained 21.1% of the explained variance in enjoyment of the WOD, although Preference did not explain unique variance in enjoyment. After accounting for age, sex, and BMI ($R^2$=0.113, or slightly more than 11%), the addition of Tolerance accounted for an additional 9.8% of the variance in enjoyment [$\beta$= 0.344, $F_{change}(1, 32)$= 3.99, $p$= 0.054]. Neither Preference nor Tolerance explained any significant variance in satisfaction with WOD performance.

The last set of analyses were to determine the affective change that occurred as a result of performing the WOD. Affective valence (FS), perceptions of energy, tiredness, tension, and calmness (AD ACL), and state anxiety were assessed before and within 5 minutes following the WOD. An initial analysis to determine if any of these affective responses differed by sex revealed no differences. As such, the responses on these measures are presented in Table 3 for pre-WOD and post-WOD. There was a significant multivariate main effect of Time [Hotelling's $T$=2.72, $F(7,29)$=11.25, $p$< 0.001]. Follow-up analyses revealed significant changes for Energy, Tiredness, Tension, and Calmness (all $p_s$< 0.001), with State Anxiety ($p$= 0.053) and Feeling Scale ($p$> 0.60) showing no significant change (all $p$= 0.17). The largest changes occurred for increased Energy ($d$= 1.44), with decreased Tiredness ($d$= 1.17) and decreased clamness ($d$= -1.01). Also of note, Tolerance was significantly associated with perceptions of exertion ($r$= 0.39, $p$= .015) and post-WOD Energy ($r$= 0.40, $p$= .011).

Table 3

Affective Responses Before and After the Workout of the Day (WOD)

| | Pre-WOD | | Post-WOD | | Effect Size | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *D* | *95% CI* |
| Feeling Scale (FS; affective valence) | 1.95 | 1.62 | 2.19 | 2.28 | 0.12 | [-0.57, 0.32] |
| Energy | 10.81 | 3.20 | 15.68 | 3.65 | 1.44 | [-2.21, -0.67] |
| Tiredness | 11.51 | 3.28 | 8.46 | 2.14 | 1.17 | [0.49, 1.74] |
| Tension | 8.19 | 2.16 | 10.22 | 2.96 | -0.79 | [-1.38, -0.21] |
| Calmness | 11.46 | 2.83 | 8.81 | 2.48 | -1.01 | [0.41, 1.61] |
| State Anxiety | 18.86 | 4.16 | 20.32 | 4.76 | -0.33 | [-1.34, 0.67] |

Affective change was also assessed using four visual analog scales (VAS; fatigue, tension, calmness, nervous; see Table 4). Analysis of pre-to-post WOD changes was done with a repeated measures analysis of variance. The multivariate main effect for Time was significant [Hotelling's $T$=2.14, $F$(4,35)=18.75, $p$< 0.001]. Follow-up analyses revealed significant changes for fatigue, calmness, and nervous (all $p_s$< 0.03), with only tension showing no significant change (all $p$= 0.17). The largest changes occurred for increased fatigue ($d$= 1.34), with decreased calmness ($d$= -0.44) and decreased nervousness ($d$= 0.43). It is worth pointing out that post-WOD FS was negatively associated with both post-WOD VAS-Fatigue ($r$= -0.55, $p$= .001) and VAS-Tension ($r$= -0.58, $p$< .001), suggesting that even though both FS scores and VAS-Fatigue and Tension scores increased following the WOD, more positive affective valence was associated with greater fatigue and Tension following the workout.

Table 4

Visual Analog Affective Responses Before and After the Workout of the Day (WOD)

| | Pre-WOD | | Post-WOD | | Effect Size | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *d* | *95% CI* |
| Fatigue | 39.31 | 18.29 | 63.64 | 18.38 | -1.34 | [-5.36, 2.67] |
| Tension | 37.77 | 20.67 | 44.36 | 27.28 | -0.28 | [-5.58, 5.03] |
| Calmness | 55.69 | 22.84 | 45.62 | 23.79 | -0.44 | [-4.67, 5.55] |
| Nervous* | 57.36 | 23.51 | 67.10 | 22.51 | -0.43 | [-5.47, 4.61] |

*Note*: with the exception of Nervous, increasing scores reflect increases in that variable. For Nervous, increasing scores reflects less nervousness/greater ‘at ease’.

As they are conceptually similar, correlations were examined between the VAS and AD ACL measures both pre-WOD and post-WOD. Prior to the bout, VAS-Fatigue was associated with Energy ($r$= -0.48, $p$= .001) and Tiredness ($r$= 0.34, $p$= .026), VAS-Tense with Tension ($r$= 0.49, $p$= .001), and VAS-Calm with Calmness ($r$= 0.47, $p$= .002). Post-WOD, the only significant relationships were between VAS-Tense and Tension ($r$= 0.39, $p$= .015) and VAS-Calm and Calmness ($r$= 0.27, $p$= .09).

# CHAPTER 5

# DISCUSSION

It has been noted that, among other things, one direction for future research in the exercise-affect domain is the examination of personality traits and other individual dfference variables to help in explaining affective responses (Ekkekakis, Hargreaves & Parfitt, 2013). Some of those factors included the preference for and tolerand of exercise intensity (Ekkekakis et al., 2005). The major aim of this study was to examine the relationship between preference for and tolerance of high intensity exercise and whether these individual factors predicted performance in a bout of high intensity exercise, specifically a CrossFit® workout of the day (i.e., WOD). All of the hypothesized outcomes were supported: greater preference for high intensity exercise and greater tolerance of high intensity exercise predicted better WOD performance (i.e., greater number of repetitions); whereas more traditional measures of extraversion did actually predict WOD performance (contrary to initial predictions), preference and tolerance explained a substantial amount of additional unique variance in performance; and preference and tolerance were associated with self-reported enjoyment and satisfaction following the WOD. As such, the assessment of preference for and tolerance of exercise intensity, via the PRETIE-Q, provided the ability to explain high intensity exercise performance.

As noted in the introduction, CrossFit® and other high intensity exercise programs (e.g., Insanity, P90X®), sometimes referred to as "extreme conditioning programs" (Bergeron et al., 2011) have become increasingly popular. While such programs often deliver important physiological benefits, little is known about whether such programs are enjoyable and whether individuals would stick with them to reap the benefits when given a choice. The present study was an initial attempt at examining this relationship.

Ekkekakis et al. (2006) showed that preference for exercise intensity predicted self-selected exercise intensity. While not exactly the same finding, the present results showed that preference predicted number of repeititions on the WOD, which is similar to self-selected intensity. In order to be able to compelte more repetitions in the given time frame, the individual had to push her/himself and exercise at a faster pace which resulted in higher exercise intensity. This is also consistent with the Ekkekakis et al. (2007) study examining tolerance of exercise intensity. Tolerance in the spresent study predicted number of WOD repetitions as well, which would indicate that those with a higher tolerance for exercise intensity could push themselves harder (i.e., work at a higher intensity) because of their ability to tolerate the discomfort and unpleasantness associated with such high intensity work.

Unlike the work by Saanijoki et al. (2015), who compared high intensity sprint training to more moderate intensity training and showed increasingly more unpleasant affective responses, the present results showed a mixed affective pattern immediately post-WOD. Feeling Scale scores increased slightly, but overall did not change. However, Energy increased and Tiredness decreased, which would indicate a more positive affective response. On the other hand, Tension increased and Calmness decreased, which would typically indicate a more negative affective response. some of this could be dur to the timing of the affective assessments , which were not done immediately after the WOD but rather within the first 5-10 minutes post-WOD. In spite of this mixed affective response, the participants were still satisfied with their workout and reported a fairly high degree of enjoyment. In fact, the enjoyment reported following the WOD was higher than similar enjoyment ratings for the HIT protocols in the work by Jung et al. (2014) with comparable ratings of perceived exertion (ratings between ‘hard’ and ‘very hard’ in both studies) and enjoyment in the work by Martinez et al. (2015). If the PACES scores from the present study are scales similarly to the PACES used by Jung et al. (where 1 of the 18 items was dropped), the enjoyment in the present study was 98.8 compared to 81 for the HIT protocol in their study. While the two exercise protocols are clearly different, the WOD in this study resulted in a fairly high degree of enjoyment, and importantly moreso in those who scored higher on Tolerance.

Consistent with the conclusions of Hall et al. (2014), the results from this study may have implications for exercise prescription. As noted by Hall et al., the guidelines put forth by the American College of Sports Medicine (2013) suggest that “the selection and progression of activities should be tailored to the preference and tolerance of each individual participant. The rationale for this recommendation is that individualization is expected to facilitate the adoption and improve long-term adherence to exercise prescriptions.” (Hall et al., 2014, p. 2250). As shown with the present data, the Preference and Tolerance scales of the PRETIE-Q can be useful in this regard (i.e., identifying individuals likely to push themselves during exercise). When developing the conceptual basis for the preference for and tolerance of exercise intensity, Ekkekakis et al. (2005) suggested that the variation in preference and tolerance likely has a genetic basis. They note, in part from human twin research, the partial to substantial heritability in preferred and tolerated intensities. This is further underscored in the work of de Geus and de Moor (2008) in their discussion of gene-by-exercise interaction. Namely, they posit that regular exercisers enjoy exercise moreso than less active individuals, in part because of the effect of genes on the variability of the affective response to acute exercise. It awaits further research, but it is possible that higher Tolerance scores on the PRETIE-Q is a reflection of the genetic predisposition to tolerate the aversive aspects of high intensity exercise, resulting in less negative affective resposnes and more enjoyment of the activity when it is done. Those with lower preference and tolerance of exercise intensity, may be best advised to “simply” engage in less intense exercise and emphasizing the rewarding aspects of the activity while de-emphasizing the unpleasant aspects (de Geus & de Moor, 2008).

Perhaps related to the idea suggested by de Geus and de Moor (2008), a possible explanation for the findings, albeit speculative based on the data collected, is that Tolerance explained performance and enjoyment of the WOD because of hemodynamic responses in the prefrontal cortex (PFC). Tempest and Parfitt (2016) examined both hemodynamic and affective responses to an incremenetal exercise test to volitional exhaustion. While certainly not the same exercise activity, they showed several things, including that Tolerance impacted duration of the test. Specifically those with higher Tolerance were able to continue to exercise despite increasing intensity and the accompanying increase in unpleasantness and discomfort, particularly as the intensity approached maximal levels. Those individuals with higher Tolerance (based on PRETIE-Q scores) had an adequate oxygen supply [i.e., greater blood flow and oxygen extraction, based on near-infrared spectroscopy (NIRS)] in PFC relative to what was needed, compared to those with low Tolerance. Thus, the high Tolerance individual may be able to either exercise longer at higher intensities or even exercise at higher inteisities, despite increasing feelings of unpleasantness during the activity, because of a sufficient hemodynamic response that enabliesthe PFC to continue efficient function (i.e., cognitive control over buffering the negative affective response).

It is important to note that performance in a given WOD is a complex behavior, influenced by a myriad of factors, with preference and tolerance being but two of them. Other factors include physiological differences, level of training, previous experiences (coping style, performance strategies, etc), and the interactions among these. While traditional measures of extraversion did predict unique variance in WOD performance, Preference and Tolerance explained a significant amount of unique variance beyond those measures, demonstrating that they are tapping into a different aspect of extraversion (i.e., interoceptive stimuli). An extravert is typically described as someone who enjoys being with people, is full of energy, tends to be enthusiastic and experiences positive emotions, and is action-oriented. Some models of extraversion include an Activity facet, which is described as a need for leading a fast-paced, busy life, moving about quickly, energetically, and vigorously, and being involved in many activities (Goldberg et al., 2006). There is also an Excitement-Seeking facet, which describes the need for high levels of stimulation (e.g., bright lights, hustle and bustle) to avoid becoming bored and taking risks and thrill-seeking. Due to IPIP-Extraversion being significantly associated with tolerance, it would seem appropriate for exercise perscriptions to call for a high intensity and fast-paced regimen not only to satisfy a typical extraverted individual's desires, but also because that individual may better tolerate that stimulus. Conversely, knowing that a person may have low tolerance for exercise intensity would suggest that individualized exercise prescription would be better off avoiding such high intensity types of activity.

As the ACSM has said, it is important that exercise programs be tailored *for long term adherence*. Enjoyment of an activity can create better adherence to that activity. In this particular sample, enjoyment of the WOD was higher (~104) than some more traditional HIIT protocols. For example, in various HIIT protocols employed by Martinez et al. (2015) enjoyment (via the PACES) immediately post-exercise was less than or similar to enjoyment reported here (scores of 81-96). What is most important about the present study is that not only enjoyment, but maybe even more importantly behavior, were predicted by individual difference variables related to a preference for exercise intensity (behavior) and tolerance of exercise intensity (enjoyment, behavior). While certainly requiring replication and followup, the results provide support for the use of a relatively short and straightforward self-report measure as a tool for aiding in exercise prescription. The use of the PRETIE-Q could identify indiivduals for whom such high intensity exercise programs may not be preferable or tolerable. In such individuals, exercise programs like CrossFit® may sound interesting at first, but would likely result in an unenjoyable and dissatisfying experience, leading to dropout (i.e., lack of adherence). On the other hand, for those who are identified as having a higher preference for and tolerance of exercise intensity, such high intensity programs may be much more satisfying and enjoyable than continuous, moderate intensity exercise. Such individuals are more likely to push themselves harder, but to more satisfied as a result of such effort. If the ultimate goal is to get people to adopt and adhere to regular exercise, the PRETIE-Q may offer a useful approach for identifying what type of exercise program would lead to such adherence.

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