The Exercise Intensity–Affect Relationship: Evidence and Implications for Exercise Behavior

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The dual-mode theory proposes that affective responses to exercise are governed by the interplay of factors influenced by the metabolic demands of exercise intensity. This paper highlights methods and mechanisms that are central to the theory and presents evidence to demonstrate the shift in affective responses, from pleasure to displeasure, as the intensity of exercise increases and causes disruption to physiological homeostasis. The data will comprise reference to active and sedentary participants and include research that has been conducted with adults and children. The potential role of self-selected exercise intensity and self-regulation using an affective scale that involves key processes underpinning the dual-mode theory will be considered. In addition, given recent evidence that affective responses during exercise may be a determinant of future exercise behavior, the practical role of the peak-end rule will be discussed and relevant studies presented. These studies explore the application of the peak-end rule to exercise behavior and examine the influence of "peak" affective memory on future exercise intentions. [*J Exerc Sci Fit* • Vol 7 • No 2 (Suppl) • S34–S41 • 2009]

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Introduction

Recent statistics suggest that physical inactivity accounts for approximately 1.9 million deaths and 19 million disability-adjusted life-years lost (World Health Organization 2003). Over the last 15 years, governments have started to listen to health experts and recognize the physical and psychological benefits of physical activity as an alternative or complementary treatment for many illnesses and as a valid tool for the promotion of good health and prevention of illness. To date, this has been most commonly translated into recommendations of 30 minutes a day of moderate-intensity activity, 5 days a week (American College of Sports Medicine [ACSM] 2009). However, this one size fits all approach fails to take into account interindividual variables and, hence, has met with limited success. Indeed, in 1999, Ekkekakis and Petruzzello commented that "assuming a mechanistic model, whereby all people should respond similarly to a given dose of exercise would be simplistic and ultimately ineffective" (p 339). In response to this, recent research has increasingly considered individual affective responses to exercise, to understand both the mechanisms associated with the intensity–affect relationship and the impact the intensity–affect relationship may have on future exercise behavior.

This paper discusses advancements in research examining the dose-response relationship. Firstly, it will describe the dual-mode theory (Ekkekakis 2003), and highlight the methodological limitations of previous research and the mechanisms proposed to be responsible for the exercise intensity–affect relationship. Experimental studies that provide empirical evidence for both the methodological and mechanistic proposals will be identified. Secondly, it will briefly explore the potential for individual self-selection of exercise intensities, and exercise self-regulation in an attempt to avoid a level of exercise intensity associated with a negative affective response. Thirdly, it will consider affect as a determinant of exercise behavior and consider the potential

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role of the peak-end rule (Kahneman 1999). Data from ongoing research in our laboratories are presented and proposed developments are discussed.

Dual-mode Theory

The dual-mode theory (Ekkekakis & Acevedo 2006; Ekkekakis 2003) is a conceptual framework developed to explain the interindividual variability in affective responses to specific exercise intensity and advance the understanding of the dose-response relationship. A starting point for the theory was to address methodological limitations in previous dose-response research. These included how affect was measured, when it was measured, and how individual exercise intensity was determined. Ekkekakis and Petruzzello (2001a,b; 2000) provide a clear rationale for the use of a dimensional, rather than categorical, approach to the measurement of affect. With the use of the circumplex model (Russell 1980), a broad, encompassing assessment of affect, which included affective valence (pleasure-displeasure) and activation, was possible. This measurement approach could also be used pre, during and post-exercise. Research in the 1990s (Parfitt & Eston 1995; Acevedo et al. 1994; Parfitt et al. 1994) provides evidence for the dynamic nature of affective responses during exercise to post-exercise that would be missed with the simple (typically used) “pre-test post-test” design (Ekkekakis & Petruzzello 1999). Further, research also highlighted that the affective response during exercise was affected by the exercise intensity and previous activity history of the participants. Affective responses were more negative during exercise of a high intensity, with a disproportionately greater decrease in the “low-active” participants (e.g. Reed et al. 1998; Parfitt et al. 1994). Intensity in these studies was described in terms of a percentage of the participant’s estimated maximal aerobic capacity. This fails to take into account individual metabolic landmarks and as such did not adequately standardize the exercise stimulus which is critical for clarifying the dose-response intensity–affect relationship (Ekkekakis et al. 2005).

Ekkekakis and colleagues argue for the three-domain typology of exercise intensity (*moderate*, *heavy* and *severe*; Gaesser & Poole 1996) and provide a comprehensive account of the adaptational significance of these intensities and how they are integrated into the dual-mode theory (see Ekkekakis et al. 2005). Central to the theory is the interplay of cognitive processes (goals, efficacy, personality, etc.) and interocoptive cues (signals from baroreceptors, thermoreceptors, etc.) within each domain. It is hypothesized that in the *moderate* domain (below the ventilatory threshold [VT]), cognitive processes have a low-to-moderate effect on acute affective responses which should remain pleasurable as the intensity does not threaten the system. In the *heavy* domain (close to VT), cognitive factors dominate and affective responses will be variable with some individuals interpreting the intensity as pleasurable and others as displeasurable. In the *severe* domain (above VT), affective responses will be mostly of displeasure as the intensity poses a substantial threat to the system. On the cessation of the exercise stimulus, there is hypothesized to be a uniform shift toward pleasure.

A growing body of empirical work has examined the tenets of the dual-mode theory. This has included studies that have mapped affective and physiological responses to maximal incremental tests and demonstrated the transition from aerobic to anaerobic metabolism in active (Ekkekakis et al. 2004) and sedentary (Welch et al. 2007) adults and children (Sheppard & Parfitt 2008); the patterning of affective change pre-, during and post-exercise at intensities set to test the theory; and greater interindividual variability in response close to (at VT) and below the VT compared with the above VT condition. To map the transition from aerobic to anaerobic metabolism, graded exercise tests were conducted with physiological and psychological responses collected throughout. Data support the uniform decline in affect after VT, but indicate variability at VT—especially in sedentary adults and children (see Sheppard & Parfitt 2008; Welch et al. 2007; Ekkekakis et al. 2004). To explore the pattern of affective change, following incremental exercise tests to identify metabolically equivalent exercise intensities, participants (e.g. healthy active adults: Ekkekakis et al. 2008; sedentary men: Parfitt et al. 2006; sedentary women: Rose & Parfitt 2007; and active children: Sheppard & Parfitt 2008) completed acute bouts of exercise at intensities relative to the ventilatory or lactate threshold. Data support a negative decline in affect during exercise above VT, but a stable positive response below VT with responses rebounding and similar post-exercise across intensities (see Figures 1 and 2 which illustrate this patterning). Analyses of individual responses support the homogeneity of response above the VT, with approximately 80% of participants declining in affect in the above VT condition, compared to variability in affect at VT and below VT. Perhaps relevant from a future exercise behavior perspective is the average decrease in affect at these intensities. This has typically

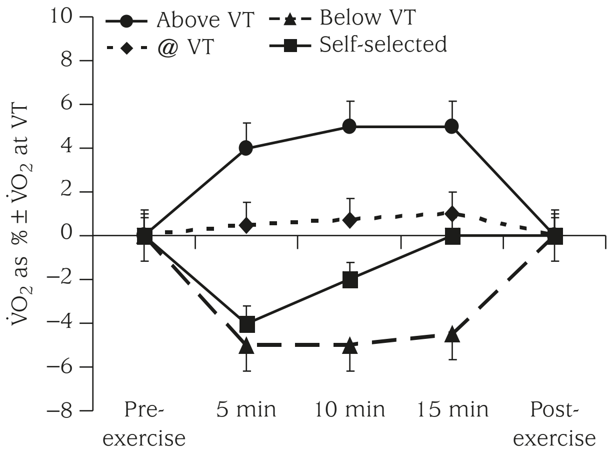

Fig. 1 Stylized representation of physiological responses relative to the ventilatory threshold (VT) during exercise in below VT, at VT, above VT and self-selected intensity conditions.

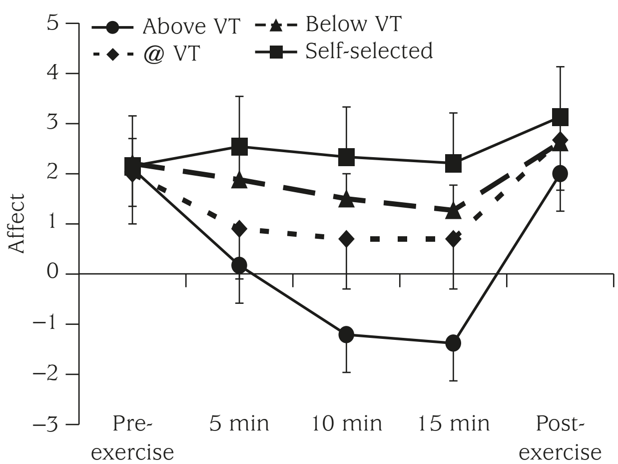

Fig. 2 Stylized representation of affective valence responses during exercise in below ventilatory threshold (VT), at VT, above VT and self-selected intensity conditions.

averaged 1–2 units at VT and below VT, but greater than 3 units above VT (Ekkekakis et al. 2008; Rose & Parfitt 2007; Parfitt et al. 2006). Qualitative data (Rose & Parfitt 2007) support the interindividual variability in response at the different intensities and also the role of cognitive factors (for example, perception of ability, interpretation of the intensity, outcomes from exercise), and the assorted interpretation of the interoceptive cues during exercise at the three domains of intensity.

Self-selection of Exercise

Over the last three decades, researchers (e.g. Williams 2008; Ekkekakis & Lind 2006; Parfitt et al. 2006; Dishman et al. 1994; Dishman 1987; Sallis et al. 1986; Morgan 1985) have called for the consideration of individual preferences when prescribing exercise programs and hence giving individuals a sense of ownership over their physical behavior. A survey by King et al. (1990) of 399 company employees, with differing ages and exercise behaviors, illustrated a greater interest in exercise if employees were able to select the mode, intensity, and duration of exercise themselves. One explanation for this is that individuals resent being "told" what intensity and duration to exercise at, and that this inherent fear of loss of control can have a detrimental effect on future behavior (Reynolds 2001; Markland 1999; Nix et al. 1999). From an exercise perspective, Morgan (1985) suggested that "it is quite probable that investigators who ask participants in research studies to exercise at their *customary* or *preferred* level of intensity would be more likely to observe positive psychological outcomes than investigators who require all individuals to exercise at the same intensity (e.g. 70% $\dot{V}O_{2max}$), because the latter (i.e. non-preferred) might be perceived as aversive" (p 9).

Self-determination theory (Deci & Ryan 1985) provides one motivational framework that supports the inclusion of preference in the exercise environment. When provided with choice or preference, an individual's autonomy is being supported. This perceived control itself could lead to a more positive affective experience, greater levels of enjoyment and enhanced intrinsic motivation (Vallerand & Rousseau 2001). In studies where exercise mode preference (Parfitt & Gledhill 2004; Daley & Maynard 2003) or exercise intensity preference (Lind et al. 2008, 2005; Rose & Parfitt 2007; Parfitt et al. 2006; Ekkekakis & Lind 2005; Focht & Hausenblas 2003; Dishman et al. 1994) have been manipulated, data support the beneficial effect on acute affective responses. Further, in directly assessing the role of autonomy, recent evidence with sedentary Greek women indicates that a loss of autonomy in setting the exercise intensity negatively influenced exercise motivation and some affective responses (Vazou-Ekkekakis & Ekkekakis 2009). In the context of health promotion, choice and positive affective responses may be fundamental in the avoidance of the "revolving door" phenomenon (individuals quitting an exercise program soon after commencing; Dishman 2001).

The primary concern of exercise practitioners, from a health promotion perspective, is the need to ensure that individuals who commence an exercise program are working at an intensity that will confer physiological benefits. Importantly, when allowed choice, studies have demonstrated that individuals self-select an intensity close to their VT or lactate threshold (Lind et al. 2008; Rose & Parfitt 2007; Parfitt et al. 2006; Lind et al. 2005) or an intensity which would confer cardiovascular gains (Vazou-Ekkekakis & Ekkekakis 2009; Focht & Hausenblas 2003; Glass & Chvala 2001; Parfitt et al. 2000; Dishman et al. 1994) according to the ACSM (2009) guidelines. These results can be explained using the proposals of the dual-mode theory with participants selecting an intensity that did not threaten physiological homeostasis (i.e. they selected an intensity that was below or around the anaerobic threshold). Participants potentially used the cognitive appraisal process and the resultant affective response to guide their intensity choice to one which resulted in a positive affective response (Rose & Parfitt 2007). However, during prescribed intensity exercise at or below VT, large interindividual differences would be observed in affective responses due to the participants' unique cognitive appraisal of the intensity.

A graphical representation of the physiological and psychological responses recorded when individuals are allowed to self-select intensity are included in the stylized graphs (Figures 1 and 2). These illustrate a positive affective response in the self-selected intensity condition that ranges between a feeling of "fairly good" (+1 on the Feeling Scale: Hardy & Rejeski 1989) and "good" (+3). These correspond to an exercise intensity close to VT. When exercise has been prescribed close to VT (or lactate threshold), affective responses have been no better than "fairly good" (e.g. Rose & Parfitt 2007).

Given recent evidence that affect may predict future exercise behavior (Williams et al. 2008), Rose & Parfitt (2008) explored the potential utility of regulating exercise intensity with affect. They demonstrated that, after one practice session, sedentary women can self-regulate exercise intensity using an affect anchor that makes them feel "good". Participants selected intensities above their VT. This placed them comfortably within a cardiovascular training zone (ACSM 2009). Ongoing research in our laboratory is exploring the experience of affect-regulated training compared to training which uses the rating of perceived exertion (RPE; Borg 1998) to regulate exercise intensity. For example, one study examined experiences of acute physiological and psychological responses to exercise training using either RPE 13 or the affect of "to feel good" (+3 on the Feeling Scale; Hardy & Rejeski 1989) to regulate training. Preliminary data support that sedentary participants preferred using the affect-regulated training and found it easy to use. Qualitative comments supported the motivational qualities and highlighted the potential role of pleasure and feeling good for behavior change. One lady using the Feeling Scale to regulate her exercise intensity commented, "I felt in control—nobody could challenge my own assessment of how good I felt. Nobody was implying that if I went faster/further/harder I would feel better for it…I didn't feel threatened by thinking I had to match up to an expected standard".

Another lady commented, "During exercise the most important thing is about your feeling, if you feel good you continue to do it, if you don't feel good you just stop. So it doesn't matter how hard you work." This latter comment reflects the underpinnings of hedonic theory (Kahneman 1999) and that the affective response (how pleasant or unpleasant it is) would influence behavior and decision-making for this individual.

With evidence starting to accumulate that links affective responses with exercise behavior and behavioral intentions (Williams et al. 2008; Kiviniemi et al. 2007), there was a call for "additional research, using prospective designs,…to understand how affective associations—which are based on past experiences with exercise—relate to acute affective responses to ongoing exercise, and ultimately, future exercise behavior" (Williams 2008, p 481).

Recent studies in our laboratory are developing this line of research. Studies have included a vignette approach, where individuals (70 and 119 adults and 189 children) read a description of an exercise experience (with the use of verbal descriptors taken from qualitative reports; Rose & Parfitt 2007) and then rate their affective and perceived exertion responses, and whether the affective response to a prescribed or self-selected intensity would influence their future exercise behavior. The first study simply required individuals to imagine that they were "10 minutes into a treadmill exercise session and were aware of their increased heart rate, their breathlessness and their heavy legs". In the prescribed condition, they were told that they had another 10 minutes to complete at the same intensity. In the self-selected condition, they were told that they could change the intensity if they so desired. Participants had to complete the Feeling Scale and RPE scale for each vignette and record on a 1–10 scale the influence their affect would have on their future exercise behavior. Participants also completed two further vignettes that described the post-exercise recovery. The reported perceived exertion was statistically higher following the reading of the prescribed condition (16.4 ± 1.8) compared to the self-selected condition (12.8 ± 2.9), even though the physiological cues were the same. Furthermore, affect was more negative ($F_{1, 68} = 4.1$, $p < 0.05$; see Figure 3) and correlated significantly with perceived influence on future behavior, with more negative affect associated with reduced future exercise behavior. When the population was split based on previous activity history, this interacting effect was accounted for by activity level, with those least active (30 minutes of activity less than once per week) reporting the most negative responses (see Figure 4).

An extension to this study was to examine what happened to affect over time. Our data show that over

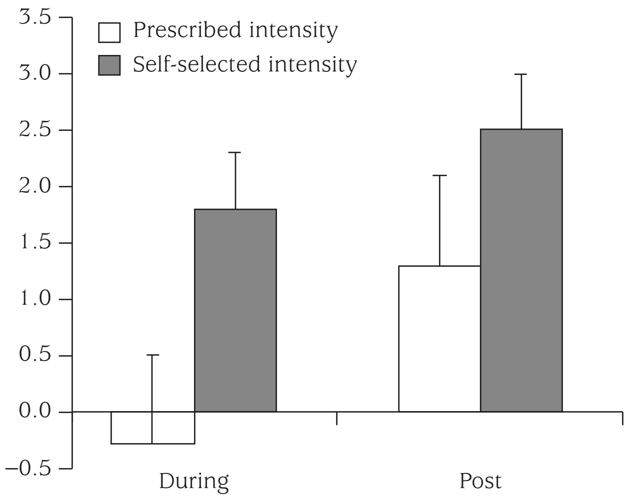

Fig. 3 Affective responses to the prescribed and self-selected intensity vignettes.

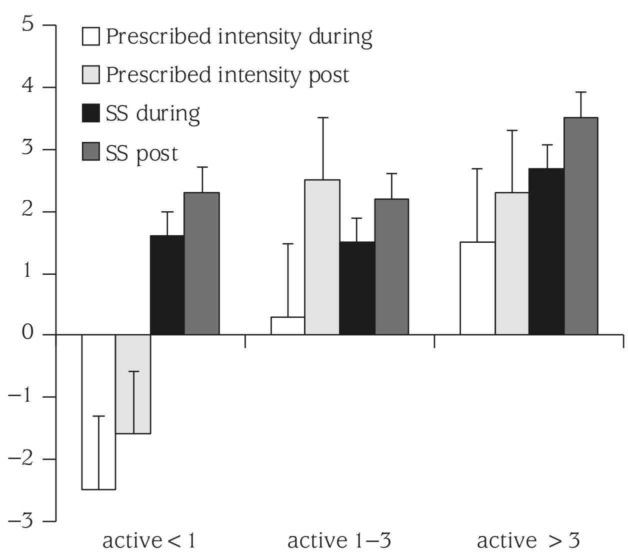

Fig. 4 Affective responses to the prescribed and self-selected (SS) intensity vignettes in low active (active < 1 per week), moderately active (active 1–3 times per week) and high active (active > 3 times per week) participants.

a 4-week period, the differential response during exercise in the prescribed and self-selected conditions was inflated when individuals were asked to recall how they think they felt (see Figure 5). This suggests that the memory of the negative experience becomes more aversive and the positive more favorable over time. Early affect–intensity research had speculated that exercisers should be encouraged to focus on how they feel after the exercise has ended rather than the negative affect experienced during exercise (Parfitt et al. 1996). This preliminary data would appear to corroborate this position and links to the role of memory in retrospective evaluations of experiences, and to support the rationale that these evaluations would influence future behavior (Fredrickson & Kahneman 1993).

Peak-end Rule

Fredrickson and Kahneman (1993) suggest that affective memory is influenced by two specific episodes during each event; the moment a distinct peak affective response is experienced, and the ending, with the duration having little effect (labeled "duration neglect"). This has recently been formulated into the *peak-end rule* (Fredrickson 2000; Kahneman 1999; Redelmeier & Kahneman 1996). The substance of this rule relies on individual capabilities to experience varying intensities of affect in order for there to be one "peak" moment which influences retrospective evaluations of any one episode. In relation to an exercise session, the "peak" transpires at the moment when the highest intensity of affect is recalled, and can be positive or negative by

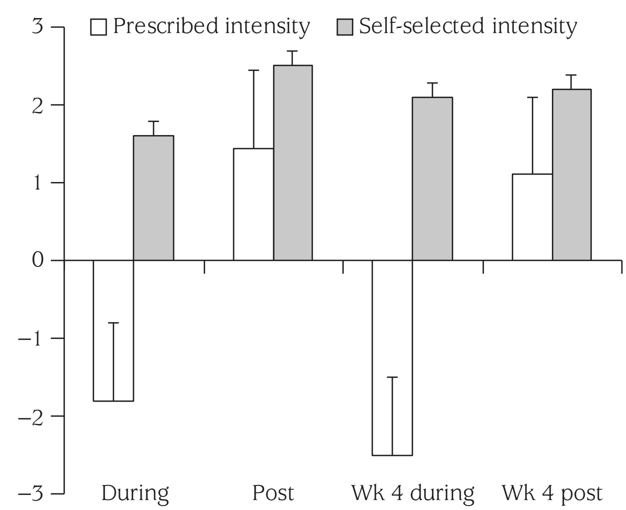

Fig. 5 Affective responses to the prescribed and self-selected intensity vignettes across a 4-week period.

nature. In contrast, the "end" is characterized by recollection of affective valence the moment the experience ends (Larsen & Fredrickson 1999; Ito et al. 1998; Varey & Kahneman 1992). Various experimental studies, that have manipulated discomfort or pain, have confirmed the peak-end rule (Kemp et al. 2008; Stone et al. 2005; Fredrickson 2000; Schreiber & Kahneman 2000; Redelmeier & Kahneman 1996; Kahneman et al. 1993), offering sound proof that the rule can be used to predict overall evaluations of episodes. This has included various settings such as autobiographical memories (Kemp et al. 2008), assessment of life quality (Diener et al. 2001) and recall of pain (Stone et al. 2005; Redelmeier & Kahneman 1996).

However, very little research has applied the rule to evaluate individual experiences of exercise, and hence identify motivational factors affecting individual attraction to exercise. One two-stage study within the exercise domain has been conducted (Brewer et al. 2000), which demonstrated that participants reported reduced aversion to a hypothetical exercise bout if it ended with a lower intensity. This was confirmed in their second study when participants reported that they would prefer to repeat an exercise session that ended at a lower intensity than one that was shorter in duration but at a higher intensity. The measurement of psychological factors that may be relevant to the exercise intensity stimulus and the motivational effect would have been of value. Indeed, Ekkekakis (2009) indicates that "the motivational significance of the physical activity stimulus itself represents one of the most understudied and underexploited factors possibly underlying physical activity behavior" (p 6).

The application of the dual-mode theory to the peak-end rule would suggest that individuals who exercise at an intensity above VT would record a high negative peak in affective valence and would therefore be reluctant to repeat the exercise. However those who exercised below the VT would be more likely to recall an overall positive affective evaluation of the episode and hence be more willing to continue exercising. Whilst these observations are promising, if the peak-end rule is to be applied with a view to encouraging exercise participation, a few factors identified in current literature need to be taken into consideration.

Firstly, although the majority of studies suggest equal weighting of the moment of peak affect and the end on retrospective evaluations of events, it is interesting to note that not all research bows to these findings. In 2008, one study asked 49 students to recall their level of happiness both during, and after a week-long holiday (Kemp et al. 2008). They found that "remembered overall happiness seems to be better predicted by end happiness than by peak [...] happiness, and the comparative failure of the peak-end rule appears to stem more from the peak than from the end" (p 137). Secondly, to date, studies have tended to focus on experiences evoking negative affect (Stone et al. 2005; Ariely & Carmon 2003; Schreiber & Kahneman 2000), with few employing pleasant stimuli to test the validity of the rule.

A dominant trend throughout research on the peak-end rule is that studies have consistently identified the lack of influence of duration (duration neglect) on overall recollection of an event (Stone et al. 2005; Fredrickson 2000; Schreiber & Kahneman 2000; Schwartz & Strack 1999; Redelmeier & Kahneman 1996; Fredrickson & Kahneman 1993). These studies have demonstrated that duration had "little or no effect on retrospective global evaluations" (Kahneman 1999, p 19). Common sense would suggest that a longer painful experience would be worse than a shorter one. However, research has consistently found that overall recollections of experienced events are summarized from a combination of the most hedonic moment, that is the "peak" and the ending, and that duration of the event has little, if any, impact (Diener et al. 2001; Fredrickson 2000; Redelmeier & Kahneman 1996; Fredrickson & Kahneman 1993).

Current research within our laboratories is examining the peak-end rule with previously sedentary participants. In a mixed method (quantitative and qualitative) study combining the dual-mode theory and peak-end rule, we are manipulating the intensity participants exercise at and assessing acute affective responses during and up to 4 weeks post exercise. We are assessing immediate post-exercise intentions and if memory of the experience changes or influences exercise decisions over the 4 weeks. The acute exercise protocol involves Group 1 exercising 10% above VT for 15 minutes and Group 2 exercising 10% above VT for 15 minutes followed by 20% below VT for 5 minutes. Evidence to date suggests that participants in Group 2 end the exercise session "more pleasantly", with statements including "*it ended nicely too, so I had time to feel good and reflect on what I had managed to achieve*", and reported starting to now do some exercise (or intentions to do so over the next week). However, participants in Group 1 reported more negative affect, and although they report accomplishment when they recall the experience (e.g. "*I remember it being hard, but pleased that I had accomplished it*"), do remember the physical demands and are less likely to comment on changes in behavior following the session.

These preliminary data provide additional encouraging support for the relevance of affective responses during exercise for future exercise participation. A positive affective response to exercise, or the memory of a positive response, may avoid the revolving door phenomena (Dishman 2001) and improve physical inactivity statistics. Indeed, from a behavior change perspective, it could be argued that we are failing all those participants who begin and subsequently quit an exercise program (typically reported to be 50%; Dishman 2001) as they are taking the first steps to change, but are then met by barriers that could include an unpleasant exercise experience. If we can identify factors that prevent the door revolving, we will fundamentally improve physical inactivity statistics. Affective responses to exercise may hold the key. The ACSM guidelines (2009) for the first time mention the relevance of affective valence in exercise prescription, but indicate that additional research is required before it (affect) can be advocated as a primary tool. This research is ongoing in several laboratories worldwide and, with the utility of appropriate methodology and theory, advances are being made.

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