

The Dual-Mode Model of Affective Responses to Exercise of Varying Intensities: A New Perspective on the Dose-Response Relationship

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Introduction

It has become clear that the relationship between exercise and affect is not unitary but rather involves multiple phenomena. At different levels of the exercise intensity continuum, there are responses of pleasure or displeasure, patterns of homogeneity or variability, and shifting relationships with cognitive and interoceptive variables. Such findings suggest that affective responses to exercise are governed by a complex mechanism.

The dual-mode model (Ekkekakis, 2003, 2005; Ekkekakis & Acevedo, in press; Ekkekakis, Hall, & Petruzzello, in press) proposes that affective responses to exercise represent manifestations of an evolved psychological mechanism, selected for its ability to promote adaptive doses of activity and inhibit non-adaptive doses. Specifically, the model predicts homogeneous pleasure responses when the intensity permits the maintenance of a physiological steady state, allowing an individual to perform physical work without causing a significant perturbation of the homeostatic system. Conversely, the model predicts homogeneous displeasure responses when the intensity is too high to allow the maintenance of a physiological steady state and exhaustion is bound to ensue within a short period of time. Furthermore, the model predicts that an intensity that is proximal to the level of transition from aerobic to anaerobic metabolism will be accompanied by variable affective responses, with some individuals reporting pleasure and others reporting displeasure. This is because this level of intensity entails a potential trade-off between benefits (e.g., ability to perform heavier work, gain access to larger territories) and risks (e.g., heightened risk of skeletomuscular injuries, cardiovascular complications, and immune suppression). Finally, the model predicts that cognitive factors (e.g., physical self-efficacy, social physique anxiety) will be the primary determinants of affective responses at intensities proximal to the aerobic-anaerobic transition, whereas interoceptive variables (e.g., respiratory or muscular cues) will gradually gain salience as the intensity approaches an individual's maximal capacity.

The purpose of the present study was to examine the tenets of the dual-mode model with a sample of middle-aged women who, having been inactive for at least one year, participated in an incremental treadmill test to volitional exhaustion. Specifically, the following hypotheses were examined: (a) pleasure will increase from baseline to the early stages of the test, (b) affective valence responses will be variable when the intensity approximates the ventilatory threshold (VT; an index of the aerobic-anaerobic transition), (c) pleasure will decrease (or displeasure will increase) when the intensity exceeds the VT, (d) there will trends toward homogeneity below and above the VT (pleasure and displeasure, respectively) and a trend toward variability near the VT, and (e) the relationship between affective valence and a cognitive variable (social physique anxiety) will be higher at intensities proximal to the VT than at the early and late stages of the treadmill test.

Main Text

Twenty-five women (age: 43 yr; body mass: 78 kg; body mass index: 28 kg/m²; estimated percent body fat: 28%; maximal oxygen uptake: 23 ml·kg⁻¹·min⁻¹) volunteered for the study. Initial screening showed that they were apparently healthy but had been inactive for at least 12 months prior to their participation in the study.

Affective valence responses were assessed with the Feeling Scale (FS; Hardy & Rejeski, 1989). The FS is an 11-point, single-item, bipolar measure of pleasure-displeasure, ranging from -5 to +5. Anchors are provided at zero ("Neutral") and at all odd integers, from "Very Good" (+5) to "Very Bad" (-5).

Social physique anxiety was assessed with the 9-item version of the Social Physique Anxiety Scale (SPAS; Martin, Rejeski, Leary, McAuley, & Bane, 1997). The SPAS is a unidimensional measure of the anxiety experienced when one perceives that his or her body is being evaluated by others.

The treadmill protocol was initiated with a walk at $1.11 \text{ m}\cdot\text{s}^{-1}$ for 2 min, which served as a warm-up. Thereafter, the speed was increased by $0.18 \text{ m}\cdot\text{s}^{-1}$ every 2 min, while the grade was always kept at 0%. This process was continued until each participant reached the point of volitional exhaustion. Responses to the FS were obtained every one min. The following five data points were retained for analysis: (a) baseline (after the facemask for the collection of expired gases was affixed on the participant's face), (b) at the end of the warm-up (min 2), (c) one min before the VT was reached, (d) one min after the VT was reached, and (e) the min at which peak oxygen uptake (VO_2peak) was reached.

A repeated-measures analysis of variance for the FS ratings provided at the five aforementioned time points showed a significant effect of time, $F(1.52, 30.37) = 7.43, p < .01$. Follow-up comparisons indicated that FS ratings improved significantly from baseline (1.67) to the end of the warm-up walk (2.71) and declined significantly from the min after the VT (1.86) to VO_2peak (0.71).

The changes in FS ratings between the five time points were also computed and the sample was subsequently divided into those who showed increases, decreases, or no change between these time points. This analysis showed that (a) from baseline to the end of warm-up, the majority of respondents (56%) showed an increase and another 37% showed no change (totalling 93%), (b) from the min after the VT to VO_2peak , the majority of respondents (63%) showed a decrease and another 33% showed no change (totalling 96%), and (c) from the min before to the min after the VT, 42% showed a decrease, 46% showed no change, and 13% showed an increase.

Finally, an examination of the product-moment correlations between SPAS and FS across the phases of the treadmill test showed a curvilinear pattern. The correlation coefficients were lower and non-significant at the early stages of the test (min 2: -.14, min 3: -.17) and near VO_2peak (min before VO_2peak : -.23; min of VO_2peak : -.35) but were higher and reached significance at intensities proximal to the VT (min of VT: -.40, $p = .06$; one min after VT: -.37, $p = .09$; two min after VT: -.45, $p = .04$). Importantly, this pattern was not the result of range restriction, as the variance in FS ratings was not diminished in the beginning and end of the test compared to the time points proximal to the VT.

Conclusions

The data from the present study illustrate that, in response to varying exercise intensities across the stages of a treadmill test to volitional exhaustion, there were responses toward pleasure (during the warm-up) and toward displeasure (from VT to VO_2peak), trends toward homogeneity (of pleasure during the warm-up and of displeasure from VT to VO_2peak) and toward variability (proximal to the VT), and shifting patterns of correlation with a cognitive variable, namely social physique anxiety (lower correlations in the beginning and end but higher correlations at intensities proximal to the VT). Overall, the findings were consistent with the predictions of the dual-mode model and agree with those from previous hypothesis-testing studies (Ekkekakis, 2003, 2005; Ekkekakis et al., in press).

Certain aspects of the results warrant further comment. First, the trends toward homogeneity, both toward pleasure during the early stages of the test and toward displeasure

during the late stages, were apparently weak, as more than one third of the participants reported no change in FS ratings during these periods. This finding is consistent with a previous study involving responses to an incremental treadmill test (Ekkekakis et al., in press). This could be explained by the very brief periods involved in such tests (one to two min), perhaps in conjunction with a response carry-over effect due to the frequent administration of the self-report measure. Second, as has also been noted previously (Ekkekakis et al., in press), there appears to be a negativity bias in affective responses to exercise, since (a) the percentage of participants reporting changes toward displeasure at high intensities has been found to be consistently higher than the percentage reporting changes toward pleasure at low intensities and (b) at intensities proximal to the VT, where the dual-mode model predicts variability of responses, the percentage of those reporting changes toward displeasure appears to be consistently higher than the percentage of those reporting changes toward pleasure. This is not entirely unexpected and it does make adaptational sense, since avoidance responses typically have greater survival value than approach responses and are, thus, more likely to contribute to Darwinian fitness. Third, the present study extends previous research in showing that the curvilinear pattern of relationships between FS and cognitive factors is not limited to physical self-efficacy (as had been demonstrated in previous studies) but also extends to social physique anxiety.

The practical implications of the present findings are the following. First, it is clear that an exercise intensity that exceeds the level of transition from aerobic to anaerobic metabolism is accompanied by significant declines in affective valence. These changes might, over time, diminish the intrinsic motivation for exercise and could have a detrimental effect on adherence. Second, there is accumulating evidence that the role of cognitive variables, such as physical self-efficacy and social physique anxiety, in influencing affective responses is diminished when the intensity approaches an individual's maximal capacity. Therefore, cognitive interventions aimed at helping novice exercisers cope with the unpleasant sensations associated with vigorous exercise might have a limited range of effectiveness. Consequently, in conjunction with cognitive techniques, practitioners should emphasize the importance of accurate self-monitoring and self-regulation of exercise intensity.

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