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Effects of Home Exercise on Immediate and Delayed Affect and Mood Among Rural Individuals at Risk for Type 2 Diabetes

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Physical activity is important for reducing overweight and obesity and related health consequences. This study examined changes in mood following 16 weeks of exercise in a sample of 29 individuals residing in a rural area and at risk for developing Type 2 diabetes mellitus (T2DM). Significant positive mood changes were detected, with moderate to large effect sizes. Assessments also revealed significant delayed postexercise positive emotion changes. These findings extend research on the mood benefits of exercise to individuals residing in rural settings and at risk for T2DM and suggest that to gain a full understanding of the exercise-affect relation, investigators need to assess affect at delayed intervals following exercise.

Keywords: *affect, exercise, mood, Type 2 diabetes*

Introduction

A great deal of attention has been directed toward the association between adverse health outcomes and sedentary lifestyle. Physical inactivity predicts a shorter life span and increased health care expenditures (Garrett, Brasure, Schmitz, Schultz, & Huber, 2004; Powell & Blair, 1994), whereas routine physical activity and exercise have numerous benefits for health and chronic disease management and increased longevity (Blair & Haskell, 2006; Blumenthal, Sherwood, LaCaille, Georgiades, & Goyal, 2005; Centers for Disease Control and Prevention [CDC], 2001; Gregg et al., 2003; Rockhill et al., 2001). These findings are particularly important for obesity and Type 2 diabetes mellitus (T2DM) because the onset and course of both may be influenced by regular exercise. In addition, obesity itself increases the risk for T2DM, and both are major causes of morbidity (e.g., coronary heart disease) and mortality in the United States and throughout the industrialized world (Mokdad et al., 2001). It is estimated that 9.3% of the U.S. population has diabetes (about 90% T2DM; Cowie et al., 2006) and approximately 32% of the U.S.

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population is obese (i.e., body mass index [BMI] $\geq$ 30). Furthermore, an alarming 61% of all individuals in the United States is overweight (i.e., BMI $\geq$ 25), and the average body weight of adults has continued to increase over the past 15 years (CDC, 2006; Ogden et al., 2006).

Obesity, sedentary lifestyle, and the sequelae thereof are an even greater concern for rural populations. The risk of being obese may be 15% higher for individuals residing in rural settings (Patterson, Moore, Probst, & Shinogle, 2004), and the odds of rural residents reporting a physically inactive lifestyle are 43% higher than for those living in urban areas (Martin et al., 2005). The relationship between physical inactivity and setting (urban vs. rural) remains even when adjustments are made for sociodemographic factors (i.e., age, level of education, and socioeconomic status; Grace, Barry-Bianchi, Stewart, Rukholm, & Nolan, 2007). Limited access to exercise facilities and characteristics of the rural environment, such as reduced availability of sidewalks or parks, have been offered as explanations for the rural-urban disparity in physical activity (Deshpande, Baker, Lovegreen, & Brownson, 2005; Wilcox, Bopp, Oberrecht, Kammermann, & McElmurray, 2003; Wilcox, Castro, King, Housemann, & Brownson, 2000). Recently, Bell et al. (2007; see also Arcury et al., 2006) documented high rates of physical inactivity and relatively low levels of ownership of home exercise equipment among rural adults with diabetes. Clearly, potential barriers to achieving adequate levels of physical activity are abundant in rural communities, placing individuals residing within these areas at increased health risk. Thus, physical activity intervention may be particularly vital for improving the health of rural individuals at risk for obesity and T2DM.

In addition to noteworthy physical health and longevity benefits, evidence supporting the psychological benefits of exercise continues to accumulate. Several reports over the past decade have documented improvement in cognitive functioning as well as decreases in anxiety or depression following regular physical activity and exercise (Barbour & Blumenthal, 2005; Eggermont & Scherder, 2006; Etnier & Berry, 2001; Penedo & Dahn, 2005). One investigation in particular found that a 16-week aerobic exercise intervention was as efficacious as an antidepressant medication in treating individuals with major depressive disorder (Blumenthal et al., 1999). At 6 months posttreatment, those individuals participating in the exercise intervention experienced lower rates of depression than those receiving the antidepressant, with only a 9% symptom relapse rate, compared to 30% for individuals who had been prescribed medication (Babyak et al., 2000). Relatively few intervention studies have investigated the effects of exercise on positive affect, but some researchers (Elavsky et al., 2005; Kolden et al., 2002) who have examined these variables have likewise demonstrated increases in positive affect and psychological well-being in their study participants. Nevertheless, this literature has been limited because of inconsistent results and populations studied. For example, Nieman, Custer, Butterworth, Uteer, and Henson (2000) found that mood states, as measured by the Profile of Mood States (POMS), did not significantly improve for a group of obese women following 12 weeks of exercise.

Regarding the present investigation, no exercise studies have examined mood effects in rural populations or individuals with or at risk for developing T2DM. The dearth of attention given to mood effects of exercise in individuals with T2DM is of particular interest, given that the prevalence of major depressive disorder is twice as high in individuals affected by diabetes (Anderson, Freedland, Clouse, & Lustman, 2001). A recent study demonstrated that individuals with both diabetes and depression are 2.5 times more likely than those with either disorder alone to die during an 8-year period (Egede, Nietert, & Zheng, 2005).

In addition to habitual regular physical activity and exercise, individual bouts of exercise have been associated with postexercise improvements in affect (Boutcher, McAuley, & Courneya, 1997;

Masters, LaCaille, & Shearer, 2003; Rejeski, Gauvin, Hobson, & Norris, 1995). For example, depression and anxiety have been found to decrease, whereas vigor and happiness have been found to increase following a session of exercise. Gauvin, Rejeski, and Norris (1996) found that an acute bout of vigorous physical activity was associated with improvements in positive feeling states (i.e., revitalization, engagement, tranquility) on the Exercise Induced Feeling Inventory (EFI). In addition, mood and affect may continue to improve following exercise and physical activity. In a group of healthy runners, O'Halloran, Murphy, and Webster (2004) found that affective improvements (i.e., increased elation and clear headedness, decreased anxiety) were not generally evident until 40 minutes into a treadmill run, but persisted at an assessment 10 minutes following the exercise bout.

Several studies have indicated that affect improvements may peak within 5 minutes following exercise (Ekkekakis, Hall, Van Landuyt, & Petruzzello, 2000; Petruzzello, Hall, & Ekkekakis, 2001; Steptoe, Kearsley, & Walters, 1993) and persist between 20 minutes to 4 hours postexercise (Focht & Hausenblas, 2001; Masters et al., 2003; Raglin & Morgan, 1987; Steptoe & Bolton, 1988). In a meta-analysis (Reed & Ones, 2006), acute low-to-moderate exercise doses were found to consistently yield positive affect for up to 35 minutes, with enhanced affect lasting for 30 minutes following the exercise session. In sum, the data have indicated that improvements in general mood occur following repeated exercise sessions and that improvements in short-term affect follow a particular bout of exercise. It also appears that particular affective states may be influenced differentially over time after completion of a bout of exercise. Thus, the timing of assessment of affective states following exercise may be an important variable.

A major limitation in the exercise literature pertained to the fact that most studies examining affect following single bouts of exercise have been performed on college-age populations, a group of individuals whose activity levels may be different from those of other populations. Much less information has been available on clinical samples or individuals at risk for adverse health outcomes, and the limited data that do exist have depicted less consistent results. For example, improved affect has been found in male cardiac patients (Gavin, Bethell, & Turner, 2000), but not in patients who have been diagnosed with cancer (Dimeo, Stieglitz, Novelli-Fischer, Fetscher, & Keul, 1999) and chronic fatigue (Clapp et al., 1999). Thus, examination of mood and affect following a single bout of exercise with particular clinical or at-risk samples is needed because findings with healthy, active individuals may not necessarily generalize to more clinically relevant populations.

The onset of enhanced affect following exercise may have implications for sedentary, at-risk individuals attempting to initiate and maintain exercise regimens. Importantly, improvement in positive affect during and following exercise has the potential to contribute to longer term adherence to exercise (Wing, Phelan, & Tate, 2002). A small study by Annesi, Westcott, and Gann (2004) of older sedentary women suggested that improvements in mood and fatigue following participation in a 10-week exercise program may have been associated with better adherence to exercise protocols. Thus, examination of affect immediately following an exercise bout and assessment of the responsiveness of mood following completion of an extended period of consistent exercise are important.

Purpose of the Study

The primary purpose of this study was to extend the literature on general mood and affective response to exercise to a rural population at risk for developing T2DM on the basis of their BMI, sedentary lifestyle, and age (American Diabetes Association, 2004). These particular variables were chosen because they are readily available and known by individuals and do not require a visit to a physician or performance of a specific laboratory test (e.g., HbA1c counts) that is likely not known or understood by most individuals in the at-risk rural population. Virtually all people, however, can know whether they are increasing their risk for developing T2DM on the basis of these simple variables. In particular, we were interested in addressing the relationships between (a) exercise and general mood across the duration of a 16-week exercise initiation home-based program for rural residents, and (b) specific exercise relevant affect pertaining to a single exercise session measured both immediately after exercise and following a 5-minute delay. The data analyses reported herein constitute secondary analyses from a study designed to pilot the efficacy of three cognitive-behavioral interventions delivered by paraprofessionals for initiating exercise among adults living in a rural area of the United States and at risk for T2DM. These interventions were delivered via telephone, mail, or both on a weekly basis. Details are available from the researchers. Rural residents were targeted because their rates of physical inactivity are dramatically higher than the rates of individuals residing in urban areas (Martin et al., 2005) and they are virtually absent from the exercise mood/affect literature. Thus, information about the potential mood benefits of exercise in rural populations is unknown.

Method

Participants

Currently sedentary adults ages 35 to 60 who resided in a rural area of the United States, Intermountain West, were recruited via advertisements in local newspapers to begin an exercise program of moderate intensity. This research was approved by the appropriate institutional review board, and the participants signed an informed consent document prior to participation. Potential participants initially completed a questionnaire assessing their age, height, weight, and gender. They were further screened by completing the Physical Activity Readiness Questionnaire (PAR-Q; Canadian Society for Exercise Physiology, 1994), an instrument supported by Health Canada and used as an indicator of whether individuals need to consult a physician before beginning a new exercise program. The PAR-Q is used widely throughout Canada and the United States, is nonthreatening and simple to administer and complete, and was designed for individuals aged 15 to 69 years. After meeting the age and sedentary lifestyle requirements, those who answered no to all PAR-Q questions and had a BMI (weight [kg]/height^2 [m]) greater than or equal to 25 were qualified to participate.

The final sample comprised 29 adults at risk for T2DM as defined by (a) a BMI greater than or equal to 25, (b) currently exercising less than once per week, and (c) at least 35 years of age. The mean age was 46.14 years (SD = 5.87), and the sample comprised 12 men and 17 women and was more highly educated than is representative (48% some college). Participants were 100% White (the surrounding community was 96% White, 2% Asian; U.S. Census Bureau, 2004).

Measures

POMS

The POMS is a widely used self-report instrument consisting of 65 items answered on a 5-point Likert scale of 0 (*not at all*) to 4 (*extremely*). It has six scales: Tension (nine items), Depression (five items), Anger/Hostility (12 items), Confusion (seven items), Fatigue (seven items), and Vigor (eight items). With the exception of Vigor, all scales measure negative mood (McNair, Lorr, & Droppleman, 1971). The six POMS scales have been shown to have good reliability, with internal consistency estimates ranging from .74 to .95 (Eichman, 1978; Shacham, 1983). Test-retest reliability (range of 3 days to 16 weeks) estimates show adequate stability (.65 to .75), though also demonstrating that the instrument is sensitive to detecting changes in mood (Eichman, 1978; O'Connor, 2004). Although the discriminant validity of the individual scales has been brought into question (Jacobs & Boze, 1993; Reddon, Marceau, & Holden, 1985), data based upon the multitrait-multimethod approach have suggested that the POMS has demonstrated convergent and discriminant validity with other measures of mood (Nyenhuis, Yamamoto, Luchetta, Terrien, & Parmentier, 1999). The POMS was administered prior to the submaximal treadmill test at the baseline and postintervention sessions. Participants were provided with instructions to rate their mood over the past week thus rendering an assessment of their general, characteristic mood.

EFI

The EFI is a brief self-report instrument consisting of 12 items that measure exercise relevant emotional states. The subscales include Tranquility, Positive Engagement, Revitalization, and Physical Exhaustion. Many measures of affect have been mentioned in the psychological literature, most focusing exclusively or predominantly on negative affect and few being designed specifically for measuring affect in relation to exercise. Designed to remedy these deficiencies, the EFI measures positive and negative affect specifically associated with exercise (Gauvin & Rejeski, 1993). The EFI has been shown to demonstrate concurrent and discriminant validity. Factor analysis has supported the validity of the four-factor model (the fit index exceeded .90) and Cronbach's alphas that often exceed .80 (Gauvin & Rejeski, 1993). Moreover, the EFI has been shown to be consistently sensitive to manipulations and interventions involving physical activity (Gauvin & Rejeski, 2001; Gauvin et al., 1996; Gauvin, Rejeski, & Reboussin, 2000; Rejeski et al., 1995). The EFI was administered to the participants immediately after they had completed a submaximal treadmill test during the baseline and postintervention assessments, as well as 5 minutes afterward.

Exercise Logs and Perceived Exertion

Weekly measures of exercise adherence were collected. For each day, the participants recorded whether they exercised (i.e., jogged or walked); for how long (in minutes); and at what level of perceived exertion. Participants were reminded weekly either by mail or phone to return their exercise logs. Ratings of physical exertion were based upon the Ratings of Perceived Exertion Scale (RPE; Borg, 1985). The RPE lists numbers in ascending order between 6 and 20 (e.g., 7 = *very, very light* and 19 = *very, very hard*) that correspond to individuals' perceptions of effort during exercise. Scores on the RPE have been reported to correlate with heart rate during exercise (Russell & Weeks, 1994), and the scale often is used in prescribing exercise intensity for healthy individuals as well as those participating in cardiac rehabilitation programs. Test-retest reliability is high ($\geq$ .90) following brief intervals of moderate intensity exercise as well as for bouts of exercise 4 weeks apart for a range of intensities (Ceci & Hassmen, 1991). The RPE has been used with a broad range of physical activities and settings, and it is considered a valid means of prescribing intensity of exercise (Robertson, 2001). Participants returned their exercise logs and exertion ratings weekly in postage-paid envelopes provided by the researchers.

Procedure

Prior to initiation of the 16-week exercise program, as well as upon its completion, participants arrived at an exercise physiology laboratory and completed paper-pencil measures that included the POMS. Subsequently, they underwent a submaximal treadmill test designed to estimate maximal aerobic capacity that was conducted by trained research assistants. After familiarization with the motorized treadmill and a brief warm-up, participants walked on the treadmill at a brisk but comfortable pace (approximately 2–3.5 mph) at 0% grade while wearing a heart rate monitor strapped just below the chest. After 4 minutes of brisk walking on the treadmill at 0% grade, the treadmill was raised to 5% grade for 4 minutes, at which time heart rate and subjective rating of how hard the participants thought they were working were recorded. After 8 minutes total of brisk walking, the treadmill was slowed to an easy pace and returned to 0% grade for a cool down to return heart rate to within 20 beats per minute of the initial heart rate (Ebbeling, Ward, Puleo, Widrick, & Rippe, 1991). At 8 minutes, participants averaged a heart rate of 125.45 bpm (*SD* = 11.40). A regression equation [15.1 + 21.8 (speed in mph) - 0.327 (heart rate in bpm) - 0.263 (speed * age in years) + 0.00504 (heart rate * age) + 5.98 (gender – 0 = female; 1 = male)] was used to estimate maximal aerobic capacity (Ebbeling et al., 1991). Immediately upon completion of the treadmill task, and again after a 5-minute delay, participants completed the EFI. At the end of the 16 weeks, participants averaged 122.04 bpm (*SD* = 12.54) at the 8^{th} minute of walking.

Participants were given a general exercise prescription for the 16 weeks that included frequency (five times/week); duration (30 min/session); intensity (12–14, or somewhat hard on the RPE); and mode (walk briskly and/or jog; Haskell et al., 2007). They were asked to exercise for 16 weeks and to complete weekly measures of exercise behavior to assess exercise adherence. It was emphasized to the participants that accuracy of the report of exercise behavior was crucial to the study and that it was essential that they report exactly what they did.

Each week that the participants returned the exercise adherence self-report measures, a token with their name was placed in a drawing to occur at the conclusion of the study. Three names were drawn to each receive one of the treadmills from the study; a fourth name was drawn to win $300. Thus, the more times that the individuals returned exercise behavior sheets, the greater their chances were of winning. Importantly, their chances of winning were *not* influenced by the amount of exercise they reported, but only if they returned their completed exercise behavior sheets. This system was designed to discourage inflated reports of exercise behavior and reward return of the measures.

Data Analysis

The principal questions addressed by the data analysis pertained to (a) general mood changes following 16 weeks of exercise, and (b) whether differences in exercise-relevant affect were found based upon the time of assessment in relation to completion of the bout of exercise, that is, immediately following exercise or after a 5-minute delay. Both questions were addressed through MANOVAs using Time as a within-subjects variable and the appropriate POMS or EFI scales as the dependent variables with follow-up analyses as appropriate. For analyses related to Question 1 above, Time was defined as baseline versus postintervention, whereas for analyses addressing Question 2, Time consisted of immediately postexercise versus 5-minute delay. Because all participants were sedentary at the initiation of the study, it was necessary to determine the extent to which they exercised during the 16 weeks of the program. Three measures of exercise adherence were computed: (a) average number of days per week that the participants met the exercise prescription, (b) total number of minutes per week that they exercised, and (c) days of exercise per week. Finally, we did not anticipate significant exercise-mood related differences based upon type of intervention; however, we conducted the necessary tests to address these questions. No statistically significant differences were found.

Results

Adherence

On average, the participants went from being sedentary (i.e., exercising less than 1 day per week) at baseline to exercising 3.92 (*SD* = 1.26) days per week for a total of 136.06 (*SD* = 58.66) minutes per week throughout the course of the study. On average, they met the exercise prescription on 3.54 (*SD* = 1.28) days per week. Inspection of the data revealed one outlier who reported exercising, on some measures, greater than two standard deviations above the mean. With this individual removed, the findings changed to 3.86 (*SD* = 1.23), 129.09 (*SD* = 45.91), and 3.48 (*SD* = 1.27), respectively. The pattern of exercise behavior could be described as relatively consistent throughout, with immediate increases observed at Week 1 and declining by the end of Week 16. During Week 1, participants exercised an average of 5.10 (*SD* = 1.05) times, which was their highest number for any week. At Week 16, they averaged 3.48 (*SD* = 1.76) times. Minutes exercised per week followed an identical trend. During Week 1, participants exercised an average of 161.16 minutes (*SD* = 49.53), which was their highest average for any week, and at Week 16, they averaged 123.27 minutes (*SD* = 80.79). Days of meeting the exercise prescription went from 3.97 (*SD* = 1.94) at Week 1 to 3.11 (*SD* = 2.04) at Week 16.

Mood and Affect

Descriptive statistics for each POMS and EFI scale can be seen in Tables 1 and 2.

POMS

To examine the impact of the 16 weeks of exercise on general, non-exercise-related mood, we calculated a MANOVA with Time as a within-subjects factor and all POMS scales as dependent variables. The result was significant, $F(6, 22) = 8.50$, $p < .0001$. Follow-up *t* tests and standardized mean difference effect sizes are presented in Table 1. Effect sizes were calculated according to the following formula, which corrects for the artifact of pre- and postcorrelation of within-subject measures.

$$d = \frac{\overline{X}pre - \overline{X}post}{\sqrt{(Spre^2 + Spost^2 - 2r_{12}Spre * Spost)}}$$

Significant beneficial effects were found for the subscales of Anger, Depression, Fatigue, Tension, and Vigor, with effect sizes ranging from .54 to .88.

Table 1: *Effects of 16 Weeks of Exercise on POMS Scores*

	Baseline		Postintervention				
Subscale	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*
Anger	7.28	5.90	3.93	4.81	3.03	.005	.62
Confusion	6.24	4.11	4.93	2.72	1.40	.174	.39
Depression	8.31	7.60	4.71	4.71	2.70	.012	.55
Fatigue	10.41	7.14	5.07	4.29	4.26	< .0001	.88
Tension	10.59	6.28	7.32	5.75	2.10	.046	.54
Vigor	18.56	5.03	14.82	6.68	3.04	.005	.62

Note. Vigor was reverse scored so that lower scores represent higher vigor; *df* = 28 for all *t* tests

EFI

Because affect was measured by the EFI immediately following the submaximal aerobic exercise test and at a 5-minute follow-up for both baseline and post-16-week exercise assessments, this variable was subject to several analyses. First, a repeated-measures MANOVA with Time (baseline, post) as a within-subjects factor and the EFI subscale scores obtained immediately following exercise as dependent variables found that mood measured immediately following the submaximal aerobic test was significantly improved following the 16-week intervention compared to the same measure at baseline, $F(4, 24) = 4.86$, $p = .005$. Similarly, a repeated-measures MANOVA with Time as a within-subjects factor (baseline, post) and the EFI scores obtained at 5-minute delay as the dependent variables found that mood after the delay was improved significantly at postintervention compared to baseline, $F(4, 24) = 3.60$, $p = .02$. The results of follow-up *t* tests, along with standardized mean difference effect sizes, are presented in Table 2. Significant results were found on all EFI scales for the immediate time measure and for revitalization and tranquility for the 5-minute delayed measure.

Table 2: *Effects of 16 Weeks of Exercise on EFI Scores at Immediate and 5-Minute Delay Postexercise Assessments*

	Immediate						
	Baseline		Postintervention				
Subscale	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*
Physical exhaustion	2.97	2.67	1.54	1.48	3.58	.001	– .58
Positive engagement	5.97	2.75	7.57	2.49	3.05	.01	.61
Revitalization	4.62	2.82	6.71	2.79	3.76	.001	.75
Tranquility	5.62	3.21	7.07	2.83	2.13	.04	.48
	Delay						
	Baseline		Postintervention				
Subscale	*M*	*SD*	*M*	*SD*	*t*	*p*	*d*
Physical exhaustion	1.52	2.11	.89	1.23	1.45	.16	– .35
Positive engagement	7.69	2.42	8.39	2.69	1.18	.25	.28
Revitalization	5.83	2.59	7.25	2.99	2.49	.02	.51
Tranquility	6.41	2.51	8.36	2.47	3.77	.001	.78

Note. *df* = 28 for all *t* tests

To assess the specific impact of a 5-minute delay on measurement of mood following exercise, we calculated two repeated-measures MANOVAs, with Time (immediate, delayed) as a within-subjects factor and the EFI subscales as dependent variables on both. One MANOVA assessed the impact of time of measurement on EFI scores following the baseline submaximal aerobic test, $F(4, 25) = 5.76$, $p = 002$. The second MANOVA examined the impact of time of measurement on EFI scores at the postintervention aerobic test and found similar results, $F(4, 24) = 5.93$, $p = .002$. Both MANOVAs indicated an improvement in EFI-rated affect during a 5-minute delay postexercise. Results of follow-up *t* tests and standardized mean difference effect sizes can be seen in Table 3.

Table 3: *Effects of Delay Following Exercise on EFI Subscales*

	Baseline			Postintervention		
Subscale	t	*p*	*d*	*t*	*p*	*d*
Physical exhaustion	4.76	<.001	– .58	3.10	.004	– .35
Positive engagement	4.31	<.001	.66	2.96	.006	.32
Revitalization	2.80	.009	.44	1.95	.061	.18
Tranquility	1.92	.065	.27	3.82	.001	.48

Note. t tests at baseline $df = 28$, while *t* tests at postintervention $df = 27$

The consistent changes in EFI subscales across all assessments are presented in Figure 1.

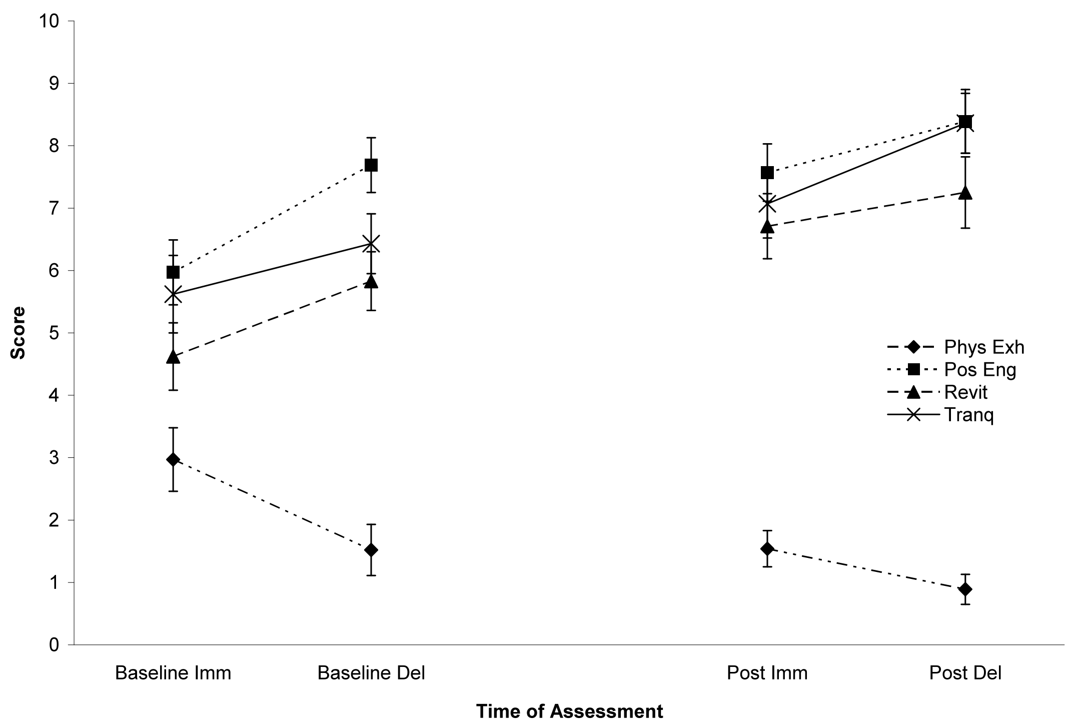

Figure 1: *EFI scores at immediate and 5-minute delay assessments for baseline and postintervention*

Discussion

The purposes of this study were to examine a rural population of initially sedentary individuals at risk for developing T2DM based upon commonly known risk factors: (a) general mood response after a 16-week exercise program, and (b) exercise relevant affective states at different time points following specific bouts of exercise. Significant mood changes on five of the six POMS subscales were detected following participation in a 16-week exercise program, with effect sizes ranging from moderate to large. All observed changes were directed toward improved mood. In addition, exercise-related affective states changed between baseline and postintervention assessments across all four EFI subscales. That is, moderate levels of increased tranquility, revitalization, positive engagement, and decreased physical exhaustion were observed. Although studies have demonstrated that exercise has health benefits for diabetes management (King et al., 2006; Smith & McFall, 2005), our investigation extends previous findings of exercise benefits by demonstrating that improved general mood and affective response also can be achieved in a group of initially sedentary individuals at risk for developing T2DM. This beneficial mood effect is of particular importance, given the association between diabetes and depressive symptoms (Anderson et al., 2001; Egede et al., 2005), and suggests that exercise may have the potential to be a useful preventive treatment for individuals at risk of developing these often comorbid conditions. Thus, examination of the improvements in mood following exercise is in need of increased emphasis in future investigations of individuals either at significant risk of developing or currently attempting to manage T2DM (and depression).

The secondary purpose of our study was to examine affective states following a 5-minute delay postexercise versus affect measured immediately following exercise. Using the four EFI subscales, improved affect was found for six of eight comparisons, with a trend toward significant improvement for the two remaining subscales. The most pronounced changes were the moderate reductions in physical exhaustion observed during 5-minute delayed assessments at baseline and postintervention; similar levels of increased positive engagement also were found. Based upon these findings, continued assessment of affective response after cessation of a bout of exercise is warranted because affective benefits appear to increase with delay, that is, the participants reported continuing improvement in affect with delay, suggesting that the actual affective benefits of exercise may be underestimated by investigators who fail to provide additional assessments following the bout of exercise.

The delayed improvements in affect observed in this study occurred after we had the participants complete a brief submaximal treadmill test that amounted to approximately 8 to 10 minutes of brisk walking. Notably, the consistent mood improvements were demonstrated in a sample of initially sedentary adults who were not reporting significant elevations or disturbances in mood or affect prior to beginning the exercise program. Although it may be somewhat surprising that a bout of exercise of such short duration would produce reliable improvements, these findings were consistent with a report by Hansen, Stevens, and Coast (2001), who found that 10 minutes of aerobic exercise of moderate intensity on a bicycle ergometer increased vigor and decreased fatigue and negative affect in a sample of healthy college-age women, with little additional psychological improvement noted for longer workouts. Thus, engaging in brief bouts of moderate levels of physical activity may produce meaningful improvements in affective response.

This finding may be particularly important for sedentary individuals attempting to make exercise behavior changes. Improved affective states following exercise may serve to reinforce engagement in exercise and, consequently, increase the likelihood of meeting the American College of Sports Medicine's (1998) recommendation that individuals achieve 30 minutes or more of moderate physical activity over the course of the day. Support for this hypothesis was found among the correlational results from the present study that revealed positive relations between exercise adherence and revitalization at follow-up (minutes per week exercise, $r[28] = .40$, $p < .05$; days per week exercise, $r[28] = .43$, $p < .05$; days per week met prescription, $r[28] = .47$; $p < .01$). Consequently, individuals who accumulate the recommended amounts of exercise in shorter bouts dispersed throughout the day may find this strategy convenient and may also experience fewer undesirable side effects (e.g., muscle soreness) than individuals who exercise for longer time periods, though continuing to obtain the health and affect benefits. Should this be determined to be a stable finding, public health officials might consider incorporating it into exercise advocacy campaigns.

Although a strength of the present study was the initiation and adherence to the 16-week exercise program with individuals residing in rural settings, the sample size was small, and the participants were highly educated. Thus, replication with greater numbers and more diverse participant populations is indicated. The study also lacked a no-exercise control group to assess for changes resulting from attention involved in participating in a study and not due to exercise per se. Nevertheless, baseline measures of the participants' mood while sedentary were consistent with nonclinical normative samples (McNair et al., 1971), indicating that the participants in our study did not experience mood disturbances or extreme preexercise scores that could have been susceptible to regression to the mean effects. Assessment of affective responses beyond a 5-minute delay also is recommended because recent data have suggested that some individuals may experience positive-activated affect for up to 30 minutes following exercise before returning to baseline levels (Gavin et al., 2000). Thus, the importance of such delayed improvements should not be overlooked. Interventions with components that encourage or emphasize the self-monitoring and recording of affect states for several minutes following completion of a bout of exercise may make this benefit more salient to those initiating exercise. Thus, health educators working with rural residents to incorporate physical activity into T2DM self-management programs may want to highlight the potential for improved mood immediately following physical activity as well as after initiation of an exercise regimen. Finally, measurement of exercise adherence relied upon the participants' self-reports. Though there is evidence that self-report is a reliable, valid, and accurate method of assessing physical activity (Bowles, FitzGerald, Morrow, Jackson, & Blair, 2004; Kurtze, Rangul, Hustvedt, & Flanders, 2008), and the pattern of reported exercise in this study matched typical patterns and expectations (i.e., initial large increase followed by gradual reduction over time), objective monitoring of exercise would strengthen these findings.

We found that the sedentary rural residents in this study who were at risk for developing T2DM experienced both long-term and immediate improvements in mood associated with exercise. Improvements in mood following an individual bout of exercise appeared to increase with delay, suggesting that researchers take this into consideration when designing future studies. Mood-enhancing effects of exercise have immediate reinforcement properties, and highlighting these benefits to exercise initiators may lead to improved exercise adherence.

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