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Does Tailoring on Additional Theoretical Constructs Enhance the Efficacy of a Print-based Physical Activity Promotion Intervention?

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Abstract

Objective—To enhance a previously efficacious individually tailored physical activity (PA) promotion intervention by adding theoretical constructs to the tailored feedback.

Design—We randomly assigned 248 healthy, underactive (moderate-vigorous physical activity [MVPA] min/week < 90) adults (Mean age=48.8; SD=10.0) to receive either: (a) a theoretically tailored (based on 5 constructs from the Transtheoretical Model [TTM] and Social Cognitive Theory [SCT]) print-based PA promotion intervention (*Print*) or (b) the same theoretically tailored print-based PA promotion intervention plus enhanced tailoring addressing five additional SCT constructs (*Enhanced Print*).

Main Outcome Measure—The 7-day Physical Activity Recall administered at baseline, month 6, and month 12, with outcomes operationalized as percent achieving 150 min/week of MVPA.

Results—When controlling for covariates, there was a non-significant trend in favor of Enhanced Print reflecting 46% and 50% greater odds of achieving 150 min/week of MVPA at month 6 and month 12, respectively.

Conclusion—Enhanced tailoring based on additional theoretical constructs may result in marginal improvements in physical activity outcomes.

Keywords

Individual Tailoring; Transtheoretical Model; Social Cognitive Theory

Twenty years ago the United States Department of Health and Human Services identified the need to increase rates of regular moderate-to-vigorous physical activity (MVPA) as a priority for improving national health (USDHHS, 1991). Since that time, prevalence rates for regular MVPA have not improved (Carlson, Fulton, Galuska, & Kruger, 2008) while there have been increases in rates of chronic diseases tied to sedentary behavior (USDHHS, 2008).

Numerous physical activity interventions have been tested in an attempt to identify one or more efficacious approaches with the potential for wide-scale dissemination and public health impact (Marcus, Williams, Dubbert et al., 2006). Among those interventions, non-face-to-face programs may have the greatest potential impact given their capability for broad reach and high efficacy (Abrams, Orleans, Niaura et al., 1996) at a relatively low cost (Lewis, Williams, Neighbors, Jakicic, & Marcus, 2010; Seivick, Napolitano, Papandonatos et al., 2007).

A growing subset of non-face-to-face interventions have employed individual tailoring strategies based on theoretical variables previously shown to predict exercise behavior (Neville, O'Hara, & Milat, 2009). Individually tailored, print-based interventions have generally been more effective than non-tailored interventions across a range of health behavior domains, as evidenced by a recent meta-analysis of 57 studies (Noar, Benac, & Harris, 2007). The meta-analysis further indicated that intervention efficacy increased when individual tailoring was theory-based, and when more theoretical constructs were used for individual tailoring, although there were diminishing returns when tailoring was based on

six or more constructs. Additionally, among theoretical constructs used in multiple studies, social support had the greatest impact on program efficacy (Noar, Benac, & Harris, 2007).

In a study published subsequent to Noar and colleagues' (2007) meta-analysis, we tested a print-based, individually tailored physical activity promotion program among healthy, previously sedentary adults (Marcus, Napolitano, King et al., 2007a, 2007b). Participants were randomly assigned to one of three interventions: Individually tailored physical activity promotion delivered through print or through telephone, or a print-based wellness contact control. The two physical activity promotion programs differed with respect to delivery medium (print versus telephone), but were matched for program content, which was tailored based on five theoretical constructs associated with the Transtheoretical model (TTM, i.e., stage of change, decisional balance, behavioral and cognitive processes of change; Prochaska, DiClemente, & Norcross, 1992) and social cognitive theory (SCT, i.e., self-efficacy; Bandura, 1997) using a computerized expert-system. At the end of the intervention (month 12), participants in the print condition reported engaging in more MVPA than participants in the telephone and contact control conditions. Specifically, using an Intent-to-Treat (ITT) criterion that assumed no change from baseline physical activity levels among subjects lost to follow-up, print-arm participants increased minutes/week of MVPA from a mean of 20.2 (SD=24.1) at baseline to a mean of 162.4 (SD=165.2) at month 12, with approximately 50% reaching national guidelines of at least 150 min/week (Haskell, Lee, Pate et al., 2007; USDHHS, 2008) at study end.

Though superior to the contact control condition, the outcomes from our previous print-based intervention leave room for improvement, as only half of the participants reached the program goal. Thus, in the present study we compared our previous print intervention to an enhanced version, with individual tailoring based on ten theoretical constructs: five constructs from the original print-based program, plus the additional social cognitive constructs of social support, outcome expectancies, planning, goal setting, and physical activity enjoyment. We hypothesized that a greater proportion of participants who received the enhanced intervention would reach 150 min/week of MVPA than participants receiving the original intervention. We also hypothesized that participants given the enhanced intervention, versus those given the original intervention, would exhibit greater changes in the additional motivational constructs targeted in the enhanced intervention. We did not include a true control group or a non-tailored comparison group, as the critical task going forward is to identify not merely whether tailoring strategies are effective, but which tailoring strategies work best (Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008).

Methods

Participants

Participants were 248 healthy (Figure 1), underactive (MVPA min/week < 90) men and women, ages 18-65 recruited through newspaper advertisements, Intranet postings, and fliers distributed at local health fairs, churches, and physician's offices. Participants were excluded if they had the following: a body mass index (BMI) greater than 40, asthma, emphysema, chronic bronchitis, hypertension, heart disease of any kind or an abnormal electrocardiogram, stroke, chronic infectious disease, any musculoskeletal problem limiting

treadmill testing or ability to exercise, or any other serious medical condition that might make exercise unsafe. Other exclusion criteria were a schedule that would make adherence unlikely (such as very frequent travel), plans to move from the area within the next year, current or planned pregnancy, self-report of more than three alcoholic drinks per day on 5 or more days per week, hospitalization for a psychiatric disorder in the last 6 months or currently suicidal, bipolar, or psychotic, or currently using prescription medication that might impair exercise performance or tolerance (e.g., beta blockers). Participants also agreed to be randomly assigned to one of the conditions and read and signed an institutionally approved consent form. Participants were enrolled between September 2006 and April 2008, with final follow-ups conducted in April 2009.

Design and Intervention

Participants were randomized into either: (a) a previously supported (Marcus, Napolitano et al., 2007a), individually tailored, print-based program, with individual tailoring based on a total of five psychosocial constructs from the transtheoretical model and social cognitive theory (*Print*); or (b) an enhanced print intervention, with individual tailoring based on ten psychosocial constructs, including five additional constructs from social cognitive theory (*Enhanced Print*). Participants in both treatment conditions were instructed that their goal was to increase their MVPA to a level that met or exceeded national recommendations (150 min/week of MVPA Haskell et al., 2007; USDHHS, 2008). Randomization was performed following all baseline assessments. To ensure balance across gender and baseline stage of change, an urn randomization sequence was generated by the study statistician and used by the research assistant to assign participants to the two study arms (Wei & Lachin, 1988).

Participants received a brief orientation at baseline, which included approximately 10 minutes of face-to-face physical activity goal setting (Marcus, Napolitano, King et al., 2007b). Print-based intervention materials received by participants in both treatment arms at months 1-6, 8, 10, and 12 included (a) individually-tailored expert system reports; (b) physical activity manuals targeted to participants' physical activity stage of change; and (c) non-tailored tip sheets with generic physical activity information (e.g., exercising in bad weather, stretching, local walking malls and parks). Individual tailoring within the expert system reports was based on questionnaires that were sent, completed, and returned by each participant via mail approximately two weeks prior to each mailing. When questionnaires were not returned, mailings included only non-tailored information (i.e., tip sheets). All participants were assessed on all ten psychosocial constructs used to tailor the Enhanced Print expert system report. Stage of change was used to determine which of the theoretical constructs were used to tailor the individualized feedback reports (Marcus, Rossi, Selby, Niaura, & Abrams, 1992b), and thus was considered an indicator of program progress rather than a putative mechanism of the intervention.

Participants in the Enhanced Print condition received additional tailoring of feedback reports based on the five constructs added to the enhanced expert system (outcome expectancies, planning, goal setting, social support, and enjoyment). Enhanced Print participants also received additional intervention components (see Figure 2) designed to enhance self-monitoring, modeling, and social support through non-tailored means. These components

included an additional ten-minute, face-to-face goal-setting session conducted at the end of the month 6 assessment session; a mailed goal-setting sheet at nine months; a physical activity newsletter sent with each print mailing providing additional information on overcoming common barriers and indicating average min/week of MVPA among all participants enrolled in the Enhanced Print condition; pedometers to encourage greater self-monitoring; and a five-minute video (provided at baseline) modeling a physically active lifestyle. Despite these additional treatment components, participants in both treatment conditions received the same number of in-person and print-based contacts, with the exception of the additional mailed goal-setting sheet at month 9 for participants in the Enhanced Print condition.

Measures

Outcome data were collected at three time points: baseline, month 6, and month 12. These assessments consisted of an interviewer-administered 7-day Physical Activity Recall (PAR), anthropometric assessments, and a battery of psychosocial questionnaires.

Sociodemographic factors—A number of demographic factors, as well as perceived stress (Cohen, Kamarck, & Mermelstein, 1983) were assessed at baseline as potential covariates.

7-day physical activity recall (PAR)—The primary outcome measure for the study was achievement of 150 min/week of MVPA as assessed by the PAR, which was administered at our research center. The PAR is an interviewer administered measure with demonstrated validity and reliability (Blair, Haskell, Ho et al., 1985; Sallis, Haskell, Wood et al., 1985) and is sensitive to change in moderate intensity physical activity (Marcus, Lewis, Williams et al., 2007; Marcus, Napolitano et al., 2007a). The PAR interviews were conducted by a research assistant blinded to study condition. All PAR interviews were audio recorded, and a random sample ($n=91$) were scored by an external rater, with only three discordant scores identified. To assess the validity of the PAR, a subset of the participants also wore accelerometers (Actigraph LLC, 2004). Spearman correlations for MVPA as assessed by PAR and accelerometer, using accelerometer counts of 1952 and higher (Freedson, Melanson, & Sirard, 1998), were 0.37 at baseline ($n=208$), 0.55 at month 6 ($n=137$) and 0.62 at month 12 ($n=130$; for all $p < .001$).

Constructs used for individual tailoring of the Print and Enhanced Print expert system reports—The physical activity stage of change measure (Marcus, Selby, Niaura, & Rossi, 1992) assesses participants' stage of physical activity behavior change (precontemplation, contemplation, preparation, action, maintenance) consistent with the TTM (Prochaska et al., 1992). It has exhibited a Kappa index of reliability over a two-week period of 0.78 (Marcus, Selby et al., 1992) and concurrent validity demonstrated by its significant association with the PAR and estimated VO_2 peak (Marcus & Simkin, 1993). The five cognitive and five behavioral processes of change posited by the TTM (Prochaska et al., 1992) were assessed by the physical activity processes of change measure (Marcus, Rossi, Selby, Niaura, & Abrams, 1992a). Self-efficacy—perceived capability to engage in regular exercise (defined in this study as at least 150 min/week of MVPA)—was measured by the

five-item physical activity self-efficacy measure (Marcus, Selby et al., 1992). The pros and cons of engaging in regular physical activity were measured by the physical activity decisional balance instrument (Marcus, Rakowski, & Rossi, 1992). The measures used to assess cognitive and behavioral processes of change, self-efficacy, and decisional balance have previously exhibited sensitivity to change and predictive validity (Napolitano et al., 2008; Williams, Lewis, Dunsiger et al., 2008). Internal consistency for these measures at baseline in the present study ranged from .72-.89.

Added constructs used for individual tailoring of the Enhanced Print expert system reports—The ten-item goal setting and ten-item planning scales assess participants' agreement with a series of statements about frequency and techniques for goal setting and planning and have previously been predictive of physical activity behavior (Rovniak, Anderson, Winett, & Stephens, 2002). The social support for exercise scale measures the degree to which the respondent's family or friends are sources of support for physical activity participation, as well as the rewards versus punishments provided by the respondent's social network; it has been shown to correlate with physical activity behavior (Sallis, Grossman, Pinski, Patterson, & Nader, 1987). The nine-item outcome expectations scale assesses the degree to which participants agree with a series of statements regarding expected positive outcomes of exercise and has exhibited positive relationships with physical activity behavior (Resnick, Zimmerman, Orwig, Furstenberg, & Magaziner, 2000). The physical activity enjoyment scale assesses perceived attributes of physical activity (e.g., "It's very pleasant," "I dislike it,") and has been predictive of physical activity behavior (Rovniak et al., 2002; Williams, Papandonatos, Napolitano et al., 2006). Internal consistency for these measures at baseline of the present study ranged from .71-.94.

Data Analysis

Logistic regression for achieving >150 min/week MVPA at 6- and 12-month follow-up—Longitudinal physical activity outcomes were analyzed using Generalized Estimating Equations (GEE), as implemented in the Correlated Data library of Splus 8.2 (Insightful Corporation, 2007). Binary physical activity outcomes (i.e., achieving 150 min/week of MVPA) were regressed upon baseline min/week of MVPA, time, treatment arm, and baseline psychosocial and socio-demographic characteristics of study participants using binomial errors and a logit link function. Given the longitudinal nature of the study, time-varying effects of baseline covariates were examined as well, using forward selection. To maintain comparability with study findings from our earlier physical activity intervention (Marcus, Napolitano et al., 2007a), gender and seasonal effects were forced into the model, irrespective of statistical significance. A working exchangeable correlation matrix was used to accommodate within-subject correlation across time, with robust standard errors used to calculate statistical significance levels.

Continuous variables were standardized by subtracting off their baseline mean and dividing by their baseline standard deviation, based upon values from Table 1. Since baseline physical activity had its range constrained to 0-90 mins/week by study eligibility requirements, we chose to scale MVPA by the 15-minute distance separating a person completely sedentary at baseline (MPVA=0) from the average study enrollee (MPVA=15).

Study group was coded as a binary indicator with the Print arm as the reference group (Print=0, Enhanced=1). Time was coded as 0, 1 respectively at the month 6 and month 12 follow-ups. Season at the time of follow-up measures was coded using three binary indicators that contrasted each season with the spring. Gender was coded as a binary indicator (Female=0, Male=1). Model output is shown in Table 2.

Interpretation of regression coefficients: Odds Ratio to Rate Ratio conversion

—In this model parameterization, the intercept represents odds for achieving 150 min/week MVPA among a reference group of female, employed study participants that reached month 6 during the spring quarter, and reported average values of continuous covariates at baseline (e.g. 15 min/week MPVA). Terms involving time represent either change in odds of achieving 150 min/week MVPA between the month 6 and month 12 follow-ups (main effect of time) or time-varying effects of baseline covariates on the odds of achieving 150 min/week MVPA during the 12-month study period (time by covariate interactions).

In the absence of treatment by baseline covariate interactions, the effect of study group in the odds ratio scale does not depend on the values chosen for the other model covariates and is, therefore, a simple-to-convey summary of the overall treatment effect that applies equally well to all study participants. However, since most people find it easier to think in terms of percentages, rather than odds, Odds Ratios (ORs) are often misinterpreted as Rate Ratios (RRs). (i.e. a doubling of the odds of achieving 150 min/week MVPA for participants assigned to Enhanced Print rather than Standard Print may be assumed to imply that twice as many participants are likely to achieve 150 min/week MVPA in Enhanced Print as in Standard Print.) Since the success rate in the Standard Print arm is quite high, the treatment OR tends to exceed the corresponding RR, and may lead to overoptimistic conclusions about the potential impact of the intervention. A, perhaps more readily interpretable, assessment of intervention effects can be obtained by converting the regression-adjusted odds of achieving 150 min/week MVPA in each study arm to the probability scale, and using these as the basis of RR calculations. Since these calculations depend on the entire set of model covariates included in the logistic regression model (e.g., gender, season, etc.), we have chosen to limit them to the representative *reference group* of study participants described above (female, employed, reached month 6 during the spring quarter, reported average values of continuous covariates at baseline).

Exploratory linear regression for min/week of MVPA at 6- and 12-month follow-up—Parallel analyses of continuous physical activity outcomes (i.e., min/week of MVPA as measured by the PAR) were conducted using random-intercept normal linear regression models.

Between-group differences in psychosocial variables used to tailor the intervention—Between-group changes in intermediate variables used to tailor the intervention (except stage of change; see above) were examined at baseline, 6, and 12 months via two-sample *t*-tests.

Results

Baseline descriptive statistics are summarized in Table 1. Results suggest seasonal differences in recruitment rates across study arms ($p=0.013$) with the Print arm having proportionally more participants recruited during the fall, and fewer in the winter. No significant between-group differences in physical activity levels or sociodemographic variables were detected at baseline (Table 1). Overall attrition rates (Figure 1) were limited to 12.5% throughout the study period and did not differ by group at the month 6 or month 12 follow-up points. There were 22 adverse events in the Print group and 27 adverse events in the Enhanced Print group, although only three were considered serious and required discontinuation of the study (see Figure 1). Using an intent-to-treat approach, participants in the Print and Enhanced Print conditions completed 83.0% and 81.0% of the questionnaires on which the individually-tailored expert system reports were based (questionnaires not received due to study attrition or medical hold are included in the denominators).

Logistic Regression for Achieving >150 Min/Week MVPA at 6- and 12-Month Follow-up

Table 2 displays model output from a GEE logistic regression model indicating whether a study participant was able to meet or exceed 150 min/week of MVPA. Covariates associated with greater odds of achieving 150 min/week of MVPA included unemployment at baseline (OR=2.31, 95% CI=1.23, 4.33), experiencing lower perceived stress at baseline (OR=0.78, 95% CI=0.61, 0.99), and assessment in the spring versus fall (OR=0.60, 95% CI=0.39, 0.91). The effect of baseline physical activity varied with measurement occasion ($p=0.013$). There was no association between baseline physical activity and physical activity levels at month 6 follow-up ($p=0.304$). However, there was a significant association at month 12 follow-up ($p<0.001$), with participants reporting mean levels of MVPA at baseline (i.e., 15 min/week) having greater odds of achieving 150 min/week of MVPA at month 12 than participants who were completely sedentary at baseline (OR=1.44, 95% CI=1.22, 2.70). Gender did not affect odds of achieving 150 min/week of MVPA ($p=0.25$). After controlling for potential covariates, there was no main effect of treatment condition (OR=1.46, 95% CI=0.84, 2.55, $p=0.183$) or time by treatment effect ($p=0.940$) on odds of achieving 150 min/week of MVPA at either follow-up.

To further examine treatment effects, we provide both point and interval estimates for the odds of achieving 150 min/week of MVPA separately by study group and measurement time point (Table 3). After adjusting for covariates, estimated odds of achieving 150 min/week of MVPA were about 50% higher for those randomized to the Enhanced Print arm, rather than the Print arm (month 6 OR=1.46, 95% CI: 0.84, 2.55; month 12 OR= 1.50, 95% CI=0.83, 2.68).

Interpretation of Regression Coefficients: Odds Ratio to Rate Ratio Conversion

Using the relationship $\text{Probability} = \text{Odds} / (1 + \text{Odds})$, the corresponding model-based estimates of the *probability* of achieving 150 min/week of MVPA were calculated as 0.43 (95% CI: 0.32, 0.56) in Enhanced Print versus 0.35 (95% CI: 0.24, 0.47) in Standard Print at month 6, dropping to 0.37 (95% CI: 0.26, 0.50) versus 0.29 (95% CI: 0.20, 0.39) respectively at month 12 for our reference group of study participants. It can be seen that the

treatment effect appears more modest when converted to the RR scale (month 6 RR=1.23, month 12 RR=1.28) relative to the OR scale (month 6 OR=1.46, month 12 OR=1.50), emphasizing the need for correct interpretation of treatment effects reported in terms of odds ratios. Unadjusted rates of achieving 150 min/week of MVPA, calculated on the basis of the entire study sample, lead to similar conclusions (Figure 3).

Exploratory Linear Regression for Min/Week of MVPA at 6- and 12-Month Follow-up

Although our original hypotheses were in terms of achieving 150 min/week of MVPA, we conducted a comparable, exploratory analysis of continuous physical activity outcomes (i.e., min/week of MVPA as measured by the PAR). Results revealed a significant time by condition interaction ($t(197)=2.21$, $p=.029$) when accounting for the same covariates as in our primary analysis. Estimated mean min/week of MVPA among participants in the Enhanced Print arm remained essentially stable between month 6 and month 12 (132 to 137 min/week MVPA; $p=0.789$), while participants in the Print arm experienced a large and statistically significant decrease from month 6 to month 12 (141 to 97 min/week MVPA; $p=0.012$) over the same time period, representing a significant shift of 49 min/week of MVPA from month 6 to month 12 in favor of the Enhanced Print condition (95% CI: 5, 92).

Between-group Differences in Psychosocial Variables Used to Tailor the Intervention

Among theoretical constructs targeted by the intervention, the only variable to show imbalances at baseline (Cohen's $\delta = 0.29$) was Outcome Expectancies, which was elevated in the Print arm compared to the Enhanced Print arm, ($p=0.02$). Differences also emerged for Decisional Balance at month 6 ($p=0.03$), with the Enhanced Print arm reporting mean values 0.48 baseline standard units lower than the Print arm. Social support from friends was the only intermediate variable for which between-arm differences were statistically significant at month 6 ($p=0.02$) and month 12 ($p=0.01$), with the advantage of the Enhanced Print over the Print arm increasing from 0.31 to 0.44 baseline standard units across follow-ups.

Discussion

This study compared the efficacy of a previously empirically supported (Marcus, Napolitano et al., 2007a) print-based physical activity promotion program tailored on theoretical constructs from the TTM and SCT versus an enhanced print-based program with additional individual tailoring based on constructs from SCT. The results showed that, when controlling for covariates, participants in the Enhanced Print condition had 46% and 50% greater odds of achieving 150 min/week of MVPA at the month 6 and month 12 follow-ups, respectively. These results, however, were not statistically significant. Analysis of continuous outcomes (i.e., min/week of MVPA) showed a time by treatment interaction indicating that from month 6 to month 12 MVPA leveled off in the Enhanced Print condition, but decreased significantly in the Print condition. Taken together, these results suggest that additional tailoring based on SCT variables resulted in a slightly greater proportion of participants achieving physical activity recommendations than tailoring based mostly on the TTM, but that this difference was not as great as we had hoped when we powered the trial.

It should be noted that participants in our initial trial receiving the same print intervention as in the present trial reached 40% and 50% success rates for achieving 150 min/week of MVPA at month 6 and month 12, respectively, using a baseline-value-carried-forward approach to missing outcome data (Marcus, Napolitano et al., 2007a). Therefore, under an assumption of 10% dropout at each follow-up, success rates among study completers in the Print arm of the present study were anticipated to reach 44% at month 6 and 63% at month 12. We powered the present study to detect an 18% increase in success rates among Enhanced Print study completers to 62% at month 6 and 81% at month 12. However, in the present study, the unadjusted rates of achieving 150 min/week of MVPA among study completers at month 6 were 35% in the Print condition versus 42% in the Enhanced Print condition, resulting in a 7% difference in success rates across study arms that was considerably smaller than expected. Further, success rates in the two study arms declined at month 12 to 29% and 35%, respectively, instead of showing the anticipated increases seen in the previous trial (Figure 3).

Differences in sample characteristics may have contributed to these decreases in absolute levels of program success. First, a greater percentage of participants in the present trial, relative to our previous trial, were completely sedentary at baseline (64.5% versus 51.5%). Participants who reported some MVPA at baseline (15 min/week) were more likely to achieve 150 min/week of MVPA at follow-up, particularly at month 12 (44% increased odds), relative to participants who were completely sedentary at baseline. Thus, having a greater proportion of completely sedentary participants in the present trial may have contributed to the lower overall success in achieving the program goal. Second, a greater proportion of participants were from racial-ethnic minority backgrounds in the present trial relative to our previous trial, and minority status is inversely related to physical activity levels in national samples (CDC, 2005; Pleis & Lucas, 2009).

With respect to changes in the targeted theoretical constructs, we did not hypothesize differential change in self-efficacy, decisional balance, or cognitive and behavioral processes of change, since these constructs were targeted in both treatment conditions. As expected, social support from friends showed significant increases in the Enhanced Print condition relative to the Print condition at months 6 and 12. Given the apparent importance of social support based on a recent meta-analysis of individually tailored health behavior interventions (Noar et al., 2007), it is possible that the successful targeting of this variable may have led to the trend for physical activity outcomes in favor of the Enhanced Print condition.

The lack of treatment effects on other theoretical constructs may be the result of conceptual overlap among the constructs targeted in both conditions (self-efficacy, decisional balance, cognitive and behavioral processes of change) and those targeted in just the Enhanced Print condition (outcome expectancies, enjoyment, goals, planning, and social support). As suggested by Noar and colleagues (2007), such conceptual overlap among theoretical constructs may lead to diminishing returns when tailoring is based on a large number of theoretical constructs. For example, in the present study, intervention components designed to impact decisional balance (i.e., pros and cons of regular physical activity) may have also

impacted outcome expectancies given the conceptual overlap between these constructs (Williams, Anderson, & Winett, 2005).

Limitations and Future Directions

Limitations of the study include the apparent underpowering of the study. Theoretically, findings that trend in favor of hypotheses, but do not achieve statistical significance, can always be attributed to a lack of power; however, the results in the present study appear to be clinically meaningful, as the odds of achieving 150 min/week of MVPA were increased by approximately 50% for participants in the Enhanced Print condition relative to the Print condition. Moreover, while a weaker comparison condition (e.g., wait-list or contact control) would undoubtedly have resulted in “stronger effects” for treatment, by using a strong comparison condition we were able to address questions about how tailored interventions work (i.e., the added value of tailoring on additional social cognitive constructs) rather than just whether our particular intervention helps to increase MVPA (Hawkins et al., 2008; Williams, 2010).

A second limitation is that our analysis of treatment effects on the targeted theoretical constructs provides only a snapshot of the process through which the enhanced intervention may have impacted physical activity behavior. We did not present a full mediation analysis, as considerable additional space is necessary to discuss appropriate statistical modeling of the joint and independent mediation effects of the putative mediators, as assessed at multiple time points (Napolitano et al., 2008).

A third limitation of this study is that our sample may not generalize to other types of adult populations. Although we recruited more minority individuals than in our previous trial, our sample consisted of mostly women who were highly educated, within a certain age group, and of high socioeconomic status. Finally, it is not possible to disentangle the added benefit of the enhanced expert system reports from the additional intervention components delivered only to the enhanced print condition, including the additional face-to-face goal-setting session, mailed goal-setting sheet, physical activity newsletter, pedometers, and video.

Directions for future research include examination of intervention delivery channel (i.e., print, phone, Internet) as a moderator of the effects of enhanced tailoring. Additionally, in the present study, individual tailoring in both intervention arms focused on psychosocial factors. Hawkins and colleagues (2008) have distinguished this goal of tailoring from the goal of altering message processing. For example, tailoring of materials might also be based on need for stimulation (Stephenson & Southwell, 2006) or elaboration likelihood (Brinol & Petty, 2006) consistent with predominant health communication theories. Further research is also needed to examine the potential of tailored interventions to address especially relevant life conditions (e.g., ethnic minority status, health conditions, life stage) for specific populations.

Conclusions

An enhanced print-based physical activity promotion program tailored on theoretical constructs from the TTM and SCT resulted in roughly 50% greater odds of achieving national guidelines for physical activity (Haskell et al., 2007; USDHHS, 2008) than a similar

program tailored on fewer theoretical constructs. Social support was the only theoretical construct that showed greater increases among participants in the enhanced program and may account for the differences in physical activity outcomes, although further (mediation) analysis is necessary.

Although a formal cost analysis is beyond the scope of this paper, review of monetary expenditures clearly indicates that the additional cost of the enhanced program consisted mainly of development costs. These costs of developing the algorithm for the additional print-based content and associated programming were significant in terms of investigator and staff compensation. However, once intervention development was complete, the *differential delivery costs* between the Enhanced Print and Print interventions were minimal. That is, with the exception of the cost of the physical activity videos (approximately \$12 per video) provided at baseline, the pedometers (approximately \$10 per pedometer), and the printing costs of the newsletter, the cost to *deliver* the two programs was virtually identical (for a similar cost analysis see Lewis, Williams, Neighbors, Jakicic, & Marcus, 2010).

Thus, in light of the marginal relative efficacy of the enhanced program in the present study, we conclude that enhanced tailoring (e.g., doubling of tailored constructs) of existing individually-tailored behavior-change programs may be worthwhile to the extent that there is ultimately a large intended audience for the program, as there is little added delivery cost per additional participant. However, when intended audiences are small, the marginal increases in efficacy, based on findings from the present study, may not be worth the substantial developmental costs associated with enhanced tailoring.

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Figure 1.
Participant Flow Chart.

Theoretical Component	Medium for Enhancement	Enhancement
Goal-Setting	Face-to-Face Sessions	- At month 6 participants discussed progress and reformulated goals that had been initially set (for both conditions) at baseline.
	Expert System	- Participants received information on goal setting emphasizing the need for specific, short-term, realistic, challenging goals. - Participants indicated if previously stated goal was unmet; goal achievement was reinforced with positive messages.
	Additional Mailing	- At month 9, participants received a goal setting feedback sheet with a summary of their baseline and month 6 goals and a prompt to set a new goal.
Planning	Face-to-Face Sessions	- At baseline, participants discussed the importance of creating and following specific plans to meet their study goal. At the month 6 session, participants assessed their progress and created new plans, if warranted.
	Expert System	- Participants received information on the importance of making and following plans. - If participants did not meet their previously stated study goal, participants were encouraged to review their plans for meeting their study goal and make new ones, if warranted.
	Additional Mailing	- At month 9, received a feedback sheet with a summary of their baseline and month 6 plans and a prompt to make new plans to meet their study goal.
Social Support	Expert System	- Additional information on the importance of social support. - Information on strategies to increase social support.
	Newsletter Mailing	- Provided normative data on minutes of activity for study participants. - Provided information about activities in the community.
Outcome Expectancies	Expert System & Tip Sheets	- Participants received information about the physical and psychological benefits of physical activity. - Proximal benefits such as improved energy, sleep, and confidence were emphasized. - Strategies for decreasing reported expectations of proximal negative outcomes, such as time-saving strategies were highlighted.
Enjoyment	Expert System & Tip Sheets	- Examples were given of ways to increase enjoyment during physical activity. - Suggested an activity of the month that participants were encouraged to try.
Modeling	Video	- Videos provided examples of men and women of varying ages, races, and ethnicities, performing moderate intensity in a diversity of activities.
Self-Monitoring	Step-Counters	- Step-counters were used as an additional self-monitoring technique. Use of the step-counter was recorded on the monthly physical activity log.
	Expert System	- Encouraged regular wearing of the step-counter.

Figure 2.
Theory-Based Features Included in the Enhanced Print-Based Intervention.

Figure 3. Crude Percentage of Study Completers Achieving 150 Min/Week MVPA. At month 6, Enhanced Print > Print (42% vs. 35%, $p=0.338$); at month 12, Enhanced Print > Print (35% vs. 29%, $p=0.415$)

Table 1
Baseline Physical Activity Levels and Sociodemographic Factors

Variable	Overall (N=248)	Enhanced (N=124)	Print (N=124)	<i>p</i> -value
Season				
Spring	26.2	23.4	29.0	0.01
Summer	12.9	12.1	13.7	
Fall	36.7	31.5	41.9	
Winter	24.2	33.1	15.3	
Mean (SD) Age in Years	46.8 (10.0)	47.4 (9.6)	46.3 (10.4)	0.51
Gender (% Female)	87.1	86.3	87.9	0.85
Race/Ethnicity (% Non-Hispanic White)	83.5	81.5	85.5	0.45
Marital Status (% Married)	63.7	60.2	68.3	0.36
Employment (% Employed)	81.9	84.7	79.1	0.39
College Graduate (%)	59.9	56.5	63.4	0.32
Household Income > \$50,000 (%)	64.9	65.5	70.4	0.53
Cigarette Use (% Current Smokers)	5.7	4.0	7.4	0.40
Mean (SD) Body Mass Index	28.1 (4.4)	28.1 (4.4)	28.0 (4.5)	0.74
Mean (SD) MVPA (Min/Week)	14.9 (24.6)	13.2 (22.9)	16.6 (26.1)	0.27
Completely Sedentary (%)	64.5	67.7	61.3	0.35

Note. MVPA=Moderate-to-Vigorous Physical Activity.

Table 2
Odds Ratios and 95% Confidence Intervals from Longitudinal Logistic Regression Model
for Achieving 150 Min/Week MVPA at 6-Month and 12-Month Follow-up (N=248)

Variable	OR	LCL	UCL	<i>p</i> -value
<i>Intercept</i>	<i>0.53</i>	<i>0.31</i>	<i>0.88</i>	0.015
Season (Summer vs. Spring)	0.81	0.47	1.39	0.448
Season (Fall vs. Spring)	0.60	0.39	0.91	0.016
Season (Winter vs. Spring)	0.64	0.37	1.13	0.128
Gender (Male vs. Female)	1.47	0.76	2.87	0.250
Perceived Stress at Baseline (Standardized)	0.78	0.61	0.99	0.042
Employment (Unemployed vs. not)	2.31	1.23	4.33	0.009
Time	0.76	0.48	1.19	0.230
Group (Enhanced vs. Print)	1.46	0.84	2.55	0.183
Physical Activity at Baseline (Standardized)	1.09	0.92	1.30	0.304
Time * Group (Enhanced vs. Print)	1.02	0.54	1.93	0.940
Time * Physical Activity at Baseline	1.32	1.06	1.64	0.013

Note. LCL=Lower Confidence Limit; UCL=Upper Confidence Limit; Time has been coded as 0, 1 respectively at the 6-month and 12-month follow-ups; Continuous variables have been standardized by subtracting off their baseline mean and dividing by their baseline standard deviation, using overall sample values from Table 1; Intercept denotes odds for reference group obtained when setting all covariates to their default value.

Table 3
Point Estimates and 95% Confidence Intervals for Regression-Adjusted Odds of
Achieving > 150 Min/Week MVPA at 6-Month and 12-Month Follow-up (N=248)

Variable	Group	Odds	LCL	UCL
Month 6	Enhanced	0.77	0.47	1.26
	Print	0.53	0.31	0.88
	Between-Group Ratio	1.46	0.84	2.55
Month 12	Enhanced	0.59	0.35	0.99
	Print	0.40	0.25	0.64
	Between-Group Ratio	1.50	0.83	2.68
6- to 12-month Ratio	Enhanced	0.77	0.50	1.20
	Print	0.76	0.48	1.19
	Between-Group Ratio	1.02	0.54	1.93

Note. LCL=Lower Confidence Limit; UCL=Upper Confidence Limit. Reference Group: Female participants in full-time or part-time employment that reported average physical activity and perceived stress values at baseline, and reached 6-month follow-up during the spring quarter.