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A theory-based approach to explain the correlates of safe physical activity in pregnant and postpartum individuals

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Abstract

Introduction: Physical activity (PA) during pregnancy has benefits for mother and child. Engaging in PA during pregnancy helps prevent excessive weight gain, decrease the risk of gestational diabetes and preeclampsia, and lower maternal anxiety and depression. Barriers to PA during pregnancy and postpartum are multifaceted, a lack of knowledge on safe PA practices for this phase of life is an established concern. Even amongst women who are regularly physically active, pregnancy can create a decline or cessation of activity. Women report difficulties in finding evidence-based materials, rely on Internet information, and receive ambiguous messaging about pregnancy and postpartum PA from healthcare providers. During pregnancy, women could also adopt healthy lifestyle choices, but without resources to empower women through educated healthy choices in PA, this period of desired lifestyle improvements could become a missed opportunity. The project aimed to analyze the level of PA behavior in pregnant and postpartum–two years following birth, individuals living in a southwestern state in USA. It is also to examine safe PA efforts to support and increase the likelihood of adherence to behavior in this unique population.

Methods: In order to understand the factors that contribute to health behavior change for safe PA in pregnancy and postpartum, this cross-sectional study employed the fourth-generation multi-theory model (MTM) in individuals ages 18 years and older. An MTM-based 37-item pre-defined instrument for 150 minutes of safe PA was administered electronically to a local representative sample of pregnant and postpartum women in A southwestern state in USA (n = 110).

Results: The study found that in women who have been engaged in ≥ 150 minutes of PA in the last week as per recommendations, the construct of MTM, namely behavioral confidence ($\beta = 0.175$, 95% CI [-1.21, 8.12], $p < 0.001$) was statistically significant and important to initiate ≥ 150 minutes of PA, while attributing to a significant 62.9% of the variance in the likelihood to achieve ≥ 150 minutes of PA. The study also explained that two other constructs of MTM namely, emotional transformation ($\beta = 0.097$, 95% CI [-7.19, 12.36], $p < 0.001$) and changes in the social environment ($\beta = 0.048$, 95% CI [-6.97, 9.19], $p < 0.001$), respectively, accounted for a significant for maintenance of the repeated behavior of continuing ≥ 150 minutes of PA. These two constructs accounted for 39.0% of the variance.

Discussion: This evidence-based study verifies the use of MTM in facilitating PA interventions in

pregnant and postpartum women aged 18 and over. Furthermore, outcomes from these activities can be evaluated using both quantitative and qualitative methodology. This provides future physicians with the knowledge of safe PA and allows them to develop their skill set in patient education on healthy living. While findings from the MTM survey will provide guidance on areas of need to increase PA in pregnant and postpartum individuals, identifying areas for future interventions and educational resources can be developed to address these needs.

Take-home message: Interventions led by educators and healthcare providers, based on the MTM framework, may assist pregnant and postpartum women, in adhering to safe physical activity. This approach has the potential to mitigate disparities experienced by this specific population, particularly to enhance behavioral confidence and emotional transformation to achieve an active and healthy lifestyle.

Keywords: Multi-theory model of health behavior change (MTM); pregnancy; postpartum; physical activity (PA).

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INTRODUCTION

Promotion of physical activity (PA) in pregnant and postpartum women has been a novice field since the recommendations have been given by the American College of Obstetrics and Gynecology, which lacks some specific guidelines for the postpartum period (American College of Obstetrics and Gynecology [1]. According to the Centers for Disease Control and Prevention (CDC), women should do at least 150 minutes (2 hours and 30 minutes) of moderate-intensity aerobic activity a week during pregnancy and the postpartum period. Preferably, aerobic activity should be spread throughout the week. [2].

PA during pregnancy has numerous benefits to both the mother and child. For the infant, emerging evidence indicates that maternal PA has positive impacts on the baby's metabolic, hemodynamic, and behavioral health characteristics, potentially throughout their lifespan [3]. PA in the postpartum period improves weight management, reduces the risk of diabetes, and prevents depressive disorders [1]. However, in the United States, 75% of postpartum women retain weight compared to pre-pregnancy, with 47.4% and 24.4% retaining over 10 pounds and 20 pounds, respectively [4]. On the other hand, engaging in regular PA by pregnant and postpartum women has been a behavior with lesser health promotion, attention, and intervention studies and is duly attributed to a lack of data in measuring women's beliefs, attitudes, as well as enabling and inhibiting factors [5]. Socio-ecological factors have been considered as the leverage points in postpartum PA intervention programs [6]. Recommendations have been given for programs with social and group elements with an enjoyment component to engage postpartum women in PA [7].

Multiple factors hinder pregnancy and postpartum PA, one significant problem is the lack of awareness of safe techniques for PA at this stage of life. Pregnancy can lead to a decrease or complete cessation of PA, even in habitually active women [8]. Women face challenges in accessing educational resources that are supported by evidence, and they may receive conflicting or ambiguous guidance for physical exercise during pregnancy and postpartum from healthcare practitioners [9]. During pregnancy, women may also choose to pursue a healthy lifestyle [10]. However, the absence of adequate tools to enable women to make informed and healthy decisions on physical exercise may fail to seize this opportunity for desired lifestyle enhancements.

Over the past few decades, various theories of behavior change have emerged and evolved. Initial concepts primarily concentrated on interventions that were information-driven, emphasizing the importance of awareness and the transfer of knowledge. The subsequent generation of theories

shifted focus towards the development of skills. The introduction of evidence-based practices in the 1990s paved the way for third-generation theories, such as the theory of planned behavior and social cognitive theory. Presently, the innovative fourth-generation approaches leverage technology and targeted behavior modification to implement precise interventions derived from a synthesis of multiple theoretical frameworks. Many generations of behavior change theories have been studied, reflecting changes in focus and approach focused on health behavior awareness and data collecting [11]. This foundational approach presented more robust concepts. Later on, second-generation theories focused on skill development and health behavior awareness [12].

Theories offer a systematic framework for comprehending and shaping behavior, facilitating the recognition of patterns and the creation of specific interventions aimed at altering negative behaviors while encouraging positive ones. This has led to the verification of intention, perceived behavioral control, and self-control constructs of the theory of planned behavior [13] and self-determination theory [14,15] with favorable correlations with PA behavior. The relationship between a distant motivational element can be influenced by belief-based variables, e.g., attitudes and perceived behavioral control [16]. Both intention and perceived behavioral control are seen as factors influencing physical exercise behavior and mood alterations [17]. A training program based on Bandura's self-efficacy theory [18,19] has decreased the average score of depression and proven somewhat successful in preventing the escalation of both obvious and concealed anxiety among women during the postpartum phase [20].

The substantial evidence presents that psycho-social factors might affect physical symptoms and behaviors, such as increased fear of movement or kinesiophobia [21,22]. Kinesiophobia leading to restricted movement, birth related physical and psychological factors, such as trauma after an emergency cesarean section, postpartum sleep deprivation, as well as changes in body mass – all emphasize the need for a whole-systems postpartum return to PA approach [23]. Early versions of evidence-based health education programs mostly concentrated on disseminating knowledge via translational medicine. Subsequently, second-generation skill-based programs were implemented, followed by third-generation programs that concentrated on a singular theory. The current fourth-generation models pivot around interpersonal factors encompassing behavioral processes and psychosocial systems that evaluate the community and culture surrounding a postpartum woman. These models include diffusing and adopting innovation in health promotion [24] and can elucidate the determinants of PA and the sustained adherence to this behavior. One such fourth-generation evidence-based model is the multi-theory model (MTM) of health behavior change [25] and has two constructs, i.e., initiation of the behavior and sustenance of the behavior. It has been applied in many aspects of health behavior change, e.g., PA behaviors [22], stress management behaviors [23], mammography screening-related behaviors [27,28], cancer screening behaviors [29,30], substance use behavior [31], and many more (Figure 1).

The aim of this study is based on the multi-theory model (MTM) of health behavior change in predicting initiation and sustenance of PA behaviors among pregnant and postpartum individuals of A southwestern state in USA who are 18 years and older. Data from the March of Dimes indicates that there were 25,330 live births in the population of the current studied southwestern state of USA [32]. There are an estimated 465,948 women of childbearing age living within the county. To better understand this, MTM is applied to this unique population for the PA behavior. There are three constructs for initiation of behavior change are named as 1) *participatory dialogue*, comprising of *advantages* and *disadvantages*, weighing the greater inclination toward advantages than disadvantages, 2) *behavioral confidence*, is the second construct which describes the ability for a behavior change with external source of powerful others, deities, God, etc.; and 3) and the third construct relevant to environment is defined as the *changes in the physical environment* which characterizes the modalities of accessibility and attainability of resources which effectively facilitate a behavior modification. For sustenance of behavior change, there are also three constructs proposed: as 1) *emotional transformation*, which characterizes the capacity to displace emotions into goals for a behavior change; 2) the second construct is *practice for change*, which continuously emulates thoughts

about a behavior change, relevant corrections to behavior strategies, which will in turn render down barriers and enhance a health behavior change; and 3) the third construct relates to *changes in the social environment*, which integrates social and supportive networks for a sustained behavior change. The MTM has been theorized to explain the changes in behaviors to control weight at different population levels [33]. Our study explains the behavioral characteristics and outcomes of safe PA in a sample of self-reported pregnant and postpartum women, which also improves the value of evidence-based patient education on initiating and sustaining healthy lifestyle behaviors.

METHODS

Study procedure

The market research company, Qualtrics supported the data collection process for this cross-sectional study by recruiting the study respondents from a pool of participants representing the population demographics of pregnant and postpartum women in A southwestern state in USA. Data were collected from March 27, 2024 to April 10, 2024. To acquire a study panel of participants, Qualtrics collaborates with more than 20 online sample collaborators. Convenience sampling was used to recruit samples from a southwester state in the United Sates, with targeting specific zip codes. This provided diverse and representative datasets for researchers by randomly selecting likely qualifiers for sample selection of respondents. Traditional, actively managed panel portals provide most samples, and occasionally, social media is used to collect responses. By incorporating the study's inclusion criteria and guaranteeing that only qualified respondents are included, Qualtrics includes screening questions at the start of the survey. In accordance with the Qualtrics® panel agreement, all eligible respondents who finish the survey receive incentive payment. The incentives can vary anything which have been previously mentioned and included in the agreement. The inclusion criteria were females pregnant and/or having given birth in the past two years, age 18 years and older, comprehension of English language, and resident of A southwestern state in USA, United States, while the exclusion criteria were females younger than 18 years of age, not pregnant or have not given birth in the last two years, and not a resident of the under study southwestern state in United States.

Instrumentation

A 45-item survey questionnaire was evaluated based on a pre-defined MTM-based scale for PA in college students [26]. The modified scale was targeted to identify the factors associated with PA knowledge and duration in pregnant-postpartum women aged 18 years and older, being pregnant and or having given birth in the past two years, age 18 years and older, could have understood the English language, and resident of A southwestern state in USA. The survey consisted of 16 demographic questions and questions about PA duration achieving at least 150 minutes per week, as well as 29 items related to the two main theoretical constructs of MTM (initiation and sustenance).

The instrumentation review process was conducted by six topic experts who were recruited to examine the questionnaire's face and content validity. Two panel members were kinesiology experts, one had clinical expertise in obstetrics, one was not affiliated with public health, and two other experts belonged to content expertise in social and behavioral health research, public health education, health behavior instrument development, and public theories or models. The reviewers were asked to evaluate the questionnaire based on the relevance, appropriateness, and comprehensibility of items relevant to the domains being measured. After three rounds of the review process, the items' language was slightly adjusted in response to expert feedback. There were no items eliminated from the questionnaire. All the experts agreed to the adequacy of content and face validity of each of the MTM subscales. The final 45-instrument was approved with a Flesch reading score of 62.2 and a Flesch-Kincaid Grade Level of 5.8.

Intention of Initiation

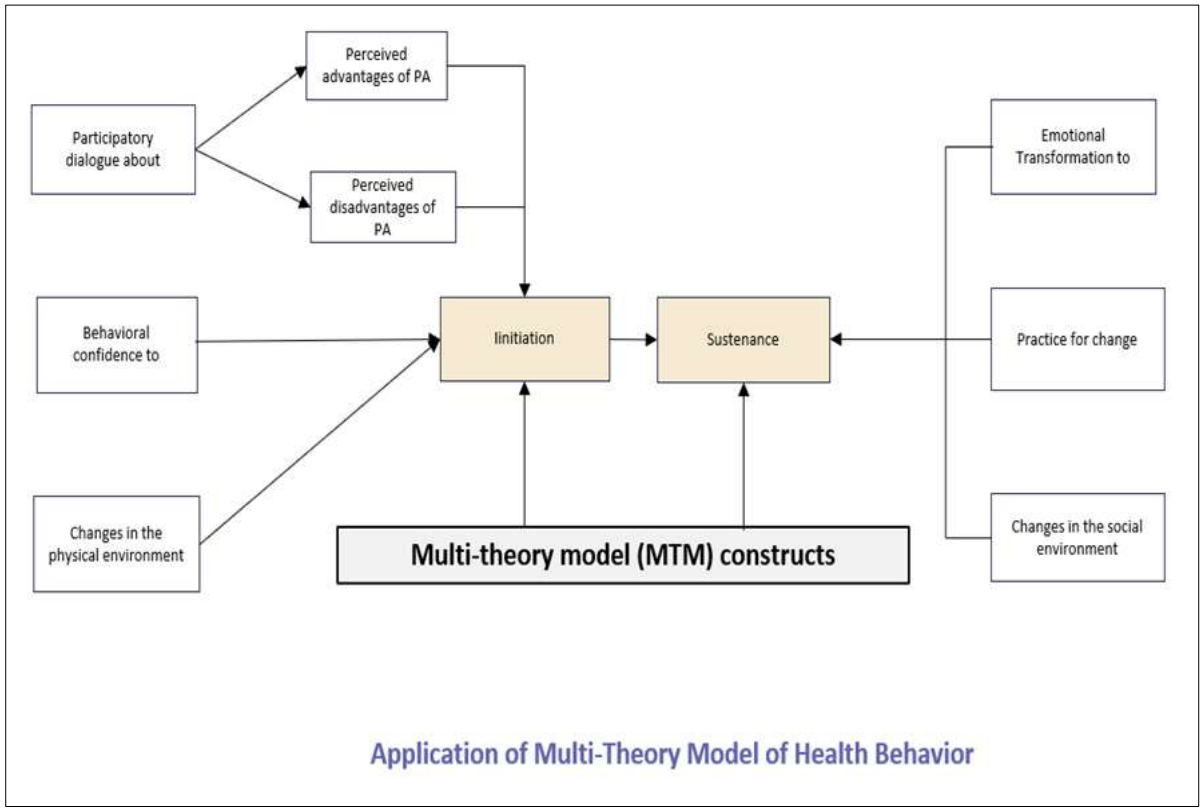
The constructs of advantages and disadvantages of the initiation construct are scored on a 5-point Likert scale, ranging from 0 to 4 [34]. The score of participatory dialogue is achieved by subtracting the total score of disadvantages from advantages. The other two constructs of initiation are behavioral confidence and changes in the physical environment. These are also scored on 5-point

Likert scale ranging from 0 to 4. A high score is associated with the greater chances of initiation of a particular behavior change process.

Intention of Sustenance

The constructs of emotional transformation, practice for change, and changes in the social environment are also operationalized on a 5-point Likert scale ranging from 0 to 4. A high score explains the higher chances toward sustenance of behavior change. Furthermore, two other variables are also included to represent the overall initiation and sustenance behavior, and also quantified as scale variables on a 5-point Likert scale ranging from 0 to 4.

Figure 1. A conceptual schema of multi-theory model and its constructs



Note: Conceptual Framework of MTM**.**

Recruitment and data collection

The recruitment of participants was launched by the Qualtrics. Participants were directed to an online survey hosted on Qualtrics (Provo, UT) upon clicking the link [35]. We utilized the 'Force Response' validation on all questions in the survey to ensure that incomplete responses were not submitted. This Qualtrics function also maintained the integrity of the survey replies by prohibiting participants from submitting more than one response. All devices were allowed and Qualtrics made checks to filter out non-human participants and utilized "RelevantID" to detect and discard fraudulent submissions.

Ethical considerations

The study (Protocol# 2023-517) was granted the exempt research status by the Institutional Review Board (IRB). The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the University of Nevada, Las Vegas (protocol # 2023-517, dated February 28, 2024). The study was entirely voluntary, and participants received comprehensive information about its goals and importance in an informed consent form that was linked to the online survey. No personal identifiers, such as name and email address, were gathered in order to maintain anonymity. Each participant was limited to providing

only one response. We employed the "Prevent Ballot Box Stuffing" feature in Qualtrics is used to prevent multiple responses from the same participant. This feature is powered by a robust algorithm to guarantee data integrity and provide distinct responses. In addition, Qualtrics employs digital fingerprinting technology to maintain the integrity of the survey.

Data integrity

The data for the study were collected and facilitated by the Qualtrics Research Services. Strict adherence to data privacy laws and regulations was ensured to maintain the integrity of the data, as it was a crucial component of the contract. The Qualtrics database does not store any sensitive information belonging to the respondents or providers. Qualtrics® facilitated the data collection and provided anonymized data to the researcher team as the database spreadsheets. The data were secured and stored on a password-protected computer in the Principal Investigators' locked offices. Access to the deidentified data files was limited to the principal investigators and statisticians of this study.

Data analysis

The data were analyzed on the statistical software packages of IBM SPSS version 29.0 (IBM Corp. Armonk, NY, USA) [36] and G* Power [37]. A number of analytical techniques were undertaken to fulfill the statistical requirements, i.e., Cohen's effect sizes conventions (based on the type of statistical test) were used for minimum sample size corresponding to 99% power [38,39]. We set the level of significance at 0.05 with 95% confidence intervals (CI). Assumptions for normality were examined as normal Q-Q plots and histograms. In addition, data were checked for homoscedasticity, sphericity, and multicollinearity demonstrated a VIF more than 1. Assumptions of normality were verified as examined by P-P plots. Independence of residuals was assessed by a Durbin–Watson statistic of nearly 2. In addition, homoscedasticity was examined by a plot of studentized residuals versus unstandardized predicted values. There was no multicollinearity noted, as explained by tolerance values greater than 0.1. There were also no studentized eliminated residuals which were greater than ±3 standard deviations, no leverage values reported more than 0.2, and Cook's distance above 1.

The mean scores of MTM constructs were compared across groups that had a total number of $\leqslant$ 149 minutes and $\geqslant$ 150 minutes of PA per week using an independent-sample t-test. Univariate, bivariate, and multivariate analyses were undertaken to compare the relationship between variables. Categorical variables were explained on frequencies/proportions and continuous variables were informed on means and standard deviations. We ran two separate Hierarchical Regression Models (HRM) to predict the variance in the initiation and sustenance of ≥ 150 minutes per week of PA or ≤ 149 minutes of PA behavior and its association with multiple factors, such as demographic characteristics and MTM constructs.

In addition, item analysis was performed for factorability and assessed based on Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity. KMO values higher than 0.80 and significant Bartlett's test results were set for factor analysis. After the factorability, factor structure of the MTM was explored by exploratory factor analysis (EFA) using principal component factor analysis with varimax rotation. The selection of the extracted factors utilized the criteria: (1) factors with eigenvalues greater than 1 and (2) items with factor loadings greater than 0.50.

RESULTS

Sample characteristics

A total of 110 participants completed this study. The mean age of the study sample was 29.92 (SD ± 4.97) years, and significant between participants performing ≤ 149 minutes and ≥ 150 minutes of PA ($p = 0.03$). Non-Hispanic represented 75% of the sample. Most participants (58.0%) were White, with almost all the participants having at least one child to whom they have given birth (Table 1). The percentage of participants with a bachelor's degree was highest (29.4%), and 38% of the population had a household income between $50K to $100K. Almost seventy percent of the participants were married, while none reported any disability.

Table 1. Comparison of Sociodemographic Characteristics of the Study Groups (N = 110).

Variable Name	Overall sample N(%)	Minutes of Physical Activity in a week		*p Value	95% Confidence Interval
	N = 110	≤ 149 minutes n=59(53.6)	≥ 150 minutes n=51(46.4)		
Age (years) M ± SD	29.92 ±4.97	29.93 ± 4.54	29.90 ± 5.44	.03	-1.919; 1.858
Number of children given birth to	1± 1.00	1 ± 1	1 ± 1	.61	-.101; .490
Ethnicity				.53	-.206; .150
Hispanic	35 (29.4)	18 (30.0)	17 (33.3)		
Non-Hispanic	75 (63)	41 (68.3)	34 (66.7)		
Race				.51	-.550; .362
White	69 (58)	38 (63.3)	31(60.8)		
Black/African American	25 (21)	13 (21.7)	12 (23.5)		
Asian	16(13.4)	8 (13.3)	8 (15.7)		
Highest Level of Education				.88	.129; 1.277
High school graduate	3 (2.5)	1 (1.7)	2 (3.9)		
Some college but no degree	16 (13.4)	12 (20.0)	4 (7.8)		
Trade school	7 (5.9)	7 (11.7)			
Bachelor's degree in college	35 (29.4)	18 (30.0)	17 (33.3)		
Master's degree	29 (24.4)	14 (23.3)	15 (29.4)		
Doctoral degree	7 (5.9)	2 (3.3)	5 (9.8)		
Professional degree (J.D., MD)	13 (10.9)	5 (8.3)	8 (15.7)		
Marital Status				<.001	.116; .617
Married	93 (78.2)	55 (91.7)	38 (74.5)		
Divorced	10 (8.4)	3 (5.0)	7 (13.7)		
Widowed	3 (2.5)	1 (1.7)	2 (3.9)		
Separated	4 (3.4)		4 (7.8)		
Annual Household Income				.25	.129; 1.277
$10,000–$50,000	19 (16.0)	14 (23.3)	5 (9.8)		
$50,000–$100,000	46 (38.7)	27 (45.0)	19 (37.3)		
$100,000–$150,000	27 (22.7)	12 (20.0)	15 (29.4)		
Above $150,000	18 (15.1)	6 (10.0)	12 (23.5)		

*Note:**p<.001 for Marital Status ; JD=Juris Doctor; MD=doctor of Medicine

Correlation and reliability diagnostics

As shown in Table 2, "participatory dialogue" was positively and strongly correlated with the "behavioral confidence" (r = 0.82, 95% CI [.75, .87], p < 0.001), "changes in the physical environment" (r = 0.64, 95% CI [.51, .74], p < 0.001), and "emotional transformation" (r = 0.67, 95% CI [.54, .76] p <0.001). Behavioral confidence had a strong positive correlation with the "changes in the physical environment" (r = 0.90, 95% CI [.85, .93], p < 0.001) and "practice for change" (r = 0.86, 95% CI [.80, .90], p < 0.001)." Behavioral confidence had a strong positive correlation with the "initiation (r = 0.92, 95% CI [.88, .94], p < 0.001). The resultant reliability (Global Cronbach's Alpha) of the tool was 0.88, with a range from 0.81 to 0.85 for subscales, describing a very good reliability.

Table 2. Zero-order Pearson correlations between MTM constructs**.**

Zero order Pearson Correlations										
	1	2	3	4	5	6	7	8	9	10
Advantages	-	-.635**	.935**	.782**	.585**	.722**	.688**	.434**	.719**	.667**
Disadvantages	-.635**	-	-.868**	-.708**	-.436**	-.649**	-.630**	-.461**	-.626**	-.605**
Participatory Dialogue	.935**	-.868**	-	.828**	.571**	.755**	.725**	.487**	.742**	.700**
Behavioral Confidence	.782**	-.708**	.828**	-	.643**	.900**	.836**	.515**	.808**	.774**
Changes in the Physical Environment	.585**	-.436**	.571**	.643**	-	.669**	.572**	.546**	.632**	.618**
Emotional Transformation	.722**	-.649**	.755**	.900**	.669**	-	.866**	.524**	.851**	.858**
Practice for Change	.688**	-.630**	.725**	.836**	.572**	.866**	-	.472**	.788**	.820**
Changes in the Social Environment	.434**	-.461**	.487**	.515**	.546**	.524**	.472**	-	.407**	.449**
Initiation	.719**	-.626**	.742**	.808**	.632**	.851**	.788**	.407**	-	.923**
Sustenance	.667**	-.605**	.700**	.774**	.618**	.858**	.820**	.449**	.923**	-
M	13.36	11.23	2.14	9.21	8.7	6.13	4.72	7.36	2	1.91
SD	4.788	3.421	7.445	5.862	2.653	3.884	3.349	2.555	1.648	1.629

Note: Global Alpha = 0.881; **Correlation is significant at the 0.01 level (2-tailed); **p < 0.01

Characteristics of study variables, item analysis, and inferential statistics

Table 3 describes the significant changes for the mean scores of initiation and sustenance constructs of MTM for individuals who did not perform 150 minutes of PA in the previous week compared to those who performed it. Noticeably, the mean score for initiation was quite higher for those who had engaged in ≥ 150 minutes of PA (M = 3.38, SD = 0.99) compared to individuals who were engaged in ≤ 149 minutes of PA (M = 0.81, SD = 1.09). Similarly, the sustenance mean score was notably higher for individuals who performed ≥ 150 minutes of PA (M = 3.28, SD = 1.09) as compared to individuals who were engaged in ≤ 149 minutes of PA (M = 0.80, SD = 1.09).

Table 4 describes the KMO test for exploratory factor analysis with values indicating good sampling adequacy. While the Bartlett's test of sphericity ($p<0.001$) also suggested that inter-item correlations were large enough to perform EFA. This is consistent with other studies on MTM [26,29,30].

Participants accomplishing ≤ 149 minutes of PA

Among the participants who had not been accomplishing ≥ 150 minutes of PA, MTM sub-scales, including "participatory dialogue" and "behavioral confidence", were significant predictors of initiating, while "emotional transformation" was a significant predictor of likelihood of sustenance of achieving ≤ 149 minutes of PA behavior with explaining 44.6% of the variance for the initiation and 41.8% in the sustenance in this group (Table 5).

Participants accomplishing ≥ 150 minutes of PA

Among the participants who had been accomplishing ≥ 150 minutes of PA, the MTM sub-scale, "behavioral confidence" was a significant predictor of initiating, while "emotional transformation", and "social environment" were significant predictors of sustaining ≥ 150 minutes of PA behavior with explaining 62.9% of the variance for the initiation and 39.0% in the sustenance in this group (Table 6).

Table 3. Descriptive statistics of Multi-Theory Model of behavior change constructs (N = 110).

	Participants doing ≤ 149 minutes of PA (n=59)			**Participants doing ≥ 150 minutes of PA (n=51)**			
Constructs	Possible Score Range	Observed Score Range	Mean ± SD	Possible Score Range	Observed Score Range	Mean ± SD	*p-value
Initiation	0-4	0-4	0.81±1.09	0-4	0-4	3.38±0.99	<0.001
Perceived Advantages	0-20	0-18	10.27±4.37	0-20	12-20	17.02±1.75	<0.001
Perceived Disadvantages	0-20	7-18	12.95±2.84	0-20	4-16	9.13±2.96	<0.001
Participatory Dialogue (PA-PDA)	-20-+20	-18-+7	-2.68±6.26	-20-+20	-2-+15	7.89±3.99	0.905
Behavioral confidence	0-24	0-16	4.97±4.23	0-24	9-20	14.30±2.79	<0.001
Changes in the physical environment	0-12	2-12	7.20±2.51	0-12	5-12	10.43±1.57	<0.001
Sustenance	0-4	0-4	0.80±1.09	0-4	1-4	3.28±1.09	<0.001
Emotional transformation	0-12	0-10	3.31±2.69	0-12	4-12	9.62±1.91	<0.001
Practice for change	0-12	0-10	2.41±2.20	0-12	1-11	7.47±2.32	<0.001
Changes in the social environment	0-12	2-11	6.32±2.25	0-12	3-12	8.77±2.28	<0.001

Note: *p<.001; PA= Perceived Advantages; PDA= Perceived Disadvantages

Table 4. Item analysis for internal consistency of the initiation and sustenance scales and subscales with exploratory factor analysis.

Scale	**Cronbach's alpha (95% CI)**	**KMO Test***	**Bartlett's test of sphericity****
Perceived Advantages	0.87 (0.83, 0.91)	0.857	< 0.001
Perceived Disadvantages	0.55 (0.41, 0.67)	0.578	< 0.001
Behavioral Confidence	0.90 (0.87, 0.92)	0.843	< 0.001
Changes in the Physical Environment	0.82 (0.76, 0.87)	0.714	< 0.001
Overall Initiation Scale	0.77 (0.70, 0.82)	0.915	< 0.001
Emotional Transformation	0.92 (0.89, 0.94)	0.762	< 0.001
Practice for Change	0.88 (0.84, 0.92)	0.714	< 0.001
Changes in the Social Environment	0.56 (0.39, 0.68)	0.586	< 0.001
Overall Sustenance Scale	0.90 (0.87, 0.93)	0.897	< 0.001
Overall Scale	0.92 (0.89, 0.94)	0.924	< 0.001

Note: *KMO Test (Kaiser-Meyer-Olkin test)=0.80; **Bartlett's test of sphericity=p<0.001

Table 5. Hierarchical Multiple Regression (HRM) predicting the likelihood of initiation and sustenance for performing ≤ 149 minutes of PA in pregnant postpartum women (n = 59).

Variables	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
	B	β	B	β	B	β	B	β
				Initiation				
(Constant)	101.00		148.624		102.01		98.837	
Age	-.639	-.093	-1.947	-.284	-1.251	-.182	-1.304	-.190
No. of Children	4.244	.099	6.926	.162	5.980	.140	6.265	.146
Ethnicity (Reference: Hispanic) Non-Hispanic	15.556	.231	11.899	.177	5.277	.078	4.444	.066
Black African American (Reference: White)	-5.196	-.070	-9.966	-.133	-6.795	-.091	-5.816	-.078
Asian	-5.989	-.066	-4.789	-.053	1.910	.021	2.154	.024
Divorced (Reference: Married)	34.801	.247	40.151	.285	29.668	.210	30.608	.217
Widowed	-15.670	-.065	-1.252	-.005	-24.854	-.104	-26.092	-.109
High school (Reference: Bachelor's Degree)	1.698	.007	11.453	.048	.554	.002	.411	.002
Some college or no degree	-9.761	-.127	-8.839	-.115	-13.568	-.176	-13.647	-.177
Masters	-3.910	-.054	-6.898	-.095	-3.788	-.052	-4.229	-.058
Doctoral	35.655	.208	22.727	.133	22.249	.130	20.548	.120
Professional (JD.MD)	18.824	.169	15.892	.143	25.068	.225	25.151	.226
Income $10K-$50K (Reference: $50K-$100K)	-7.371	-.101	-6.554	-.090	3.867	.053	5.774	.079
Income Above $150K	-37.619	-.367	-35.661	-.348	-37.215	-.363	-37.633	-.367
Participatory Dialogue			2.680**	.542	.529**	.107	.525**	.106
Behavioral Confidence					4.446**	.607	4.317**	.590
Physical Environment							.720	.058
R^2	.193		.436		.607		.608	
F	.752		2.214*		4.047**		3.724**	
Δ R2	.193		.243		.171		.002	
Δ F	.752		18.495**		18.230**		.161	
				Sustenance				
(Constant)	101.003		80.023		74.539		100.671	
How old are you today? (years)	-.639	-.093	-.494	-.072	-.377	-.055	-.359	-.052
How many children have you given birth to?	4.244	.099	.027	.001	-.724	-.017	-2.317	-.054
Ethnicity (Reference: Hispanic) Non-Hispanic	15.556	.231	4.604	.068	6.888	.102	4.646	.069
Black African American (Reference: White)	-5.196	-.070	-3.385	-.045	-4.301	-.058	-3.468	-.046
Asian	-5.989	-.066	3.811	.042	2.210	.024	2.453	.027
Divorced (Reference: Married)	34.801	.247	10.603	.075	8.661	.061	-4.446	-.032
Widowed	-15.670	-.065	-20.409	-.085	-15.981	-.067	-24.968	-.104
High school (Reference: Bachelor's Degree)	1.698	.007	-6.878	-.029	-2.028	-.008	-4.691	-.020
Some college no degree	-9.761	-.127	-18.208	-.237	-14.984	-.195	-13.176	-.171
Masters	-3.910	-.054	-6.884	-.095	-7.589	-.104	-5.705	-.078
Doctoral	35.655	.208	5.840	.034	10.897	.064	16.813	.098

Professional (JD.MD)	18.824	.169	3.804	.034	7.589	.068	2.366	.021
Income $10K-$50K (Reference: $50K-$100K)	-7.371	-.101	10.834	.149	10.356	.142	1.866	.026
Income Above $150K	-37.619	-.367	-17.880	-.175	-22.291	-.218	-6.680	-.065
Emotional Transformation			7.866**	.680	6.180**	.534	7.532**	.651
Practice for Change					2.730	.193	2.230	.157
Social Environment							-4.193	-.303
R^2	.193		.528		.542		.588	
F	.752		3.211*		3.111*		3.446**	
Δ R2	.193		.335		.014		.046	
Δ F	.752		30.562**		1.287		4.573*	

Note: * p-value < 0.05; ** p-value < 0.001; Adjusted R^2 for Model 4 (Initiation) = .446; Adjusted R^2 for Model 4 (Sustenance) = .418; JD=Juris Doctor; MD=Doctor of Medicine

Table 6. Hierarchical Multiple Regression (HRM) predicting the likelihood of initiation and sustenance for performing ≥ 150 minutes of PA in pregnant postpartum women (n = 51).

Variables	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
	B	β	B	β	B		B	β
				Initiation				
(Constant)	252.547		129.288		80.841		81.867	
Age	-2.573	-.258	.108	.011	.549	.055	.545	.055
No. of Children	23.899	.368	6.491	.100	6.292	.097	6.303	.097
Ethnicity (Reference: Hispanic) Non-Hispanic	-24.055	-.211	-6.732	-.059	-9.728	-.085	-9.614	-.084
Black African American (Reference: White)	9.141	.072	7.454	.059	8.352	.066	8.200	.065
Asian	5.331	.036	3.420	.023	7.350	.050	7.222	.049
Divorced (Reference: Married)	11.776	.075	-5.755	-.037	-.893	-.006	-.924	-.006
Widowed	-28.844	-.104	-13.627	-.049	-8.239	-.030	-8.299	-.030
Separated	124.204	.622	104.599	.524	107.816	.540	107.809*	.540
High school (Reference: Bachelor's degree)	-4.458	-.016	51.477	.186	41.603	.150	41.654	.151
Some college no degree	-11.569	-.058	-19.860	-.099	-12.032	-.060	-11.932	-.060
Masters	-2.382	-.020	-2.992	-.025	-5.482	-.047	-5.366	-.046
Doctoral	10.744	.059	-9.065	-.050	-13.960	-.077	-13.807	-.076
Professional (JD.MD)	17.108	.116	5.924	.040	2.119	.014	2.177	.015
Income $10K-$50K (Reference: $50K-$100K)	-23.904	-.132	-23.349	-.129	-23.848	-.132	-24.042	-.133
Income Above $150K	13.073	.103	3.650	.029	6.261	.049	6.250	.049
Participatory Dialogue			7.500	.535	5.892	.420	5.893	.420
Behavioral Confidence					3.457**	.175	3.457**	.175
Physical Environment							-.096	-.003
R^2	.584		.746		.763		.763	
F	3.270*		6.252**		6.237**		5.713**	
Δ R2	.584		.163		.016		.000	
Δ F	3.270		21.821**		2.268		.001	
				Sustenance				
(Constant)	252.547		177.310		172.971		160.847	
How old are you today? (years)	-2.573	-.258	-1.938	-.195	-1.936	-.194	-1.812	-.182

How many children have you given birth to?	23.899	.368	19.931	.307	19.604	.302	18.855	.290
Ethnicity (Reference: Hispanic) Non-Hispanic	-24.055	-.211	-17.856	-.157	-18.067	-.159	-18.113	-.159
Black African American (Reference: White)	9.141	.072	11.294	.089	13.390	.106	14.311	.113
Asian	5.331	.036	-.219	-.001	.224	.002	1.391	.009
Divorced (Reference: Married)	11.776	.075	14.026	.090	10.100	.065	12.301	.079
Widowed	-28.844	-.104	-22.705	-.082	-17.717	-.064	-13.854	-.050
Separated	124.204	.622	124.853	.625	127.511	.638	128.897*	.645
High school (Reference: Bachelor's Degree)	-4.458	-.016	-5.375	-.019	-9.156	-.033	-4.885	-.018
Some college no degree	-11.569	-.058	-13.790	-.069	-11.181	-.056	-11.033	-.055
Masters	-2.382	-.020	-8.694	-.074	-9.796	-.083	-9.878	-.084
Doctoral	10.744	.059	.240	.001	3.540	.020	4.521	.025
Professional (JD.MD)	17.108	.116	3.671	.025	.751	.005	.508	.003
Income $10K-$50K (Reference: $50K-$100K)	-23.904	-.132	-28.015	-.155	-22.935	-.127	-21.807	-.121
Income Above $150K	13.073	.103	14.469	.114	12.736	.101	12.230	.097
Emotional Transformation			4.951**	.186	2.981**	.112	2.582**	.097
Practice for Change					2.799	.118	2.816	.118
Social Environment							1.109**	.048
R^2	.584		.607		.613		.614	
F	3.270*		3.287*		3.072*		2.852*	
Δ R2	.584		.024		.005		.001	
Δ F	3.270*		2.059		.466		.078	

Note: * p-value < 0.05; ** p-value < 0.001; Adjusted R^2 for Initiation (Model 4) = 0.629; Adjusted R^2 for Sustenance (Model 4) = 0.39; JD=Juris Doctor; MD=Doctor of Medicine

DISCUSSION

This study aimed to describe the physical activity (PA) behavior in females aged 18 years and older who were either pregnant or postpartum. The study utilized the theoretical paradigm of MTM, for the mentioned sample of women drawn from A southwestern state in USA. The study found that for women who adhered to the ≥ 150 minutes of PA recommendations for the last week, only one construct of MTM, *behavioral confidence* (β = 0.175, 95% CI [-1.21, 8.12], $p < 0.001$), was statistically significant and crucial in their decision to initiate the PA. In addition, the marital status of being separated (β = 0.540, 95% CI [5.76, 15.79], $p < 0.05$) was also a significant contributor toward PA which is supported by previous studies [40,41]. However, age, race/ethnicity, education, and income level were not significant factors in the final calculated model. The final model reported a significant amount of variance (62.9%) in describing the factors to initiate PA, which is appraised as high in social and behavioral sciences [25,42]. Though this analysis could be considered unimportant, as women were adhering to the recommendations of safe PA being either in the pregnant or postpartum phase, the analysis was done to verify that the putative MTM components were essential for initiating the action. The study also found that the MTM constructs of *emotional transformation* (β = 0.097, 95% CI [-7.19, 12.36], p < 0.001) and *changes in the social environment* (β = 0.048, 95% CI [-6.97, 9.19], p < 0.001) were significant for maintaining the continued and repeated behavior of performing ≥ 150 minutes of PA and were attributed to 39.0% of the variance, which again is substantial [25,42].

Similar important effects for correlates of MTM were reported in the group of women not adhering to the recommendations of safe PA and performed ≤ 149 minutes of PA in the past week and in whom the *participatory dialogue* (β = 0.106, 95% CI [-9.66, 2.01], p < 0.001) accounted for 44.6% of the variance in the intention to even begin ≤ 149 minutes of PA. It is worth noting that behavioral

confidence which was significant for those adhering to ≥ 150 minutes of PA was also observed as an important factor for those who were not adhering to the PA guidelines. This is suggestive of the behavioral obstacles that this group may be facing and overcoming, regularly. Interventions that support these factors must be developed to enhance participatory dialogue and behavioral confidence in pregnant and postpartum women so that they can skillfully adhere to the PA recommendations. Regarding the intention to repeatedly perform and adhere to the recommendations of PA for ≥ 150 minutes but achieving ≤ 149 minutes of PA (sustenance), the MTM construct of sustenance, i.e., *emotional transformation* ($\beta = 0.651$, 95% CI [3.34, 11.71], $p < 0.001$) was a significant contributor accounting for 41.8% of the variance, which is quite considerable for this group [25,43]. It is important to note that the construct of MTM, i.e., emotional transformation is quite significant in its attributive role of explaining the continuation of even ≤ 149 minutes of PA behavior for those pregnant and postpartum women not following recommendations, hence emphasizing the significance of the MTM in formulating strategies to enhance ≥ 150 minutes of safe PA.

It is also worth noting that in this local southwestern state sample of pregnant and postpartum women of ages 18 and up, 53.6% of them have not even initiated the recommended level of PA in the last one week as per the recommendations for the PA given by the US Department of Health and Human Services [44]. These findings are similar to previously reported physical inactivity levels of 38.3% [45], 78.6% [46], and 79.4% [47] of pregnant and postpartum women either in pregnancy or up to 12 months postpartum. A significant proportion of pregnant and postpartum women are not adhering to the PA recommendations, and their lifestyle highlighted the necessity for educational and policy initiatives to promote PA within this demographic.

Upon meticulous examination of each component of the MTM about PA levels among pregnant and postpartum women aged 18 and older, we found several important outcomes. While this is the elementary application of the MTM used to examine safe PA behavior, particularly in pregnant and/or postpartum women within the last two years, previous studies on the MTM methodologies have also demonstrated the effectiveness of behavioral confidence and participatory dialogue. These two constructs were statistically important predictors of behavior change initiation among other populations from different age and gender groups [26,28-30]. For example, Nahar et al [26] found that these constructs in college students for PA behavior, explained 26% of the variance which is high for social and behavioral health studies. In another study, 28.6% of the variance in the possibility of setting in for mammography screening among Asian American women could be accounted for the participatory dialogue and behavioral confidence [28]. Similarly, these two constructs attributed toward the 49.5% of the variance in initiating the behavior of acquiring Pap tests among minority women [30]. In another behavioral outcome, 16.9% of the variance was explained for initiating telehealth use among college students, duly accounting the constructs of participatory dialogue and behavioral confidence in behavior change.

The variance in sustaining for the behavior change was 41.8% among women who performed ≤ 149 minutes of PA during the past week. For the final model, only one of the constructs of sustenance was found to be an important factor. The construct was emotional transformation and accounted alone for the significant likelihood of sustaining ≤ 149 minutes of PA behavior explaining 33.5% of the variance. Emotional transformation involves converting feelings into goals of performing and continuing at least ≤ 149 minutes of PA among pregnant and postpartum women. These findings highlighted the importance of incorporating emotional transformation in interventions aimed at promoting safe PA among pregnant and postpartum women. Several studies have found that the construct of emotional transformation is effective and a statistically significant predictor of maintaining behavior changes [26]. For instance, Nahar et al. [26] found that the construct of emotional transformation explained 29.7% of the variance in the likelihood of maintaining PA in college students.

On the other hand, in our study, we did not find any significant relationship between participatory dialogue and changes in the physical environment, together with the construct for practice for change in performing and continuing ≥ 150 minutes of PA. The mentioned deficiency of

relationship can be applied to the individualistic approach of PA behavior, which is generally reflected by personal capabilities and physical constraints that are both internal and external factors and influence the life of pregnant and postpartum women. This absence of correlation can be ascribed to the individualized characteristics of PA behavior, predominantly shaped by personal decisions, physical limitations, sedentary lifestyle [48-50]. Several studies support this fact. For instance, Okafor and Goon [51] highlighted the need of increased in personnel and infrastructure for antenatal sessions, physical exercise courses, and counseling in conjunction with stakeholders to conduct periodic prenatal PA programs. To our knowledge, this is the first study in A southwestern state in USA to assess the PA behavior in this unique population. We described that our theoretical approach can be applied to a larger sample to understand PA behavior in different ethnic and minority groups of pregnant or postpartum women if they encounter barriers in information about safe PA. As such significant obstacles to PA have been reported among different racial ethnic groups of pregnant or postpartum individuals [52,53]. Effective approaches targeting intrapersonal, interpersonal, sociocultural/demographic, physical environment, and healthcare environment will assist in delivering counseling initiatives to enhance PA in this distinct demographic population [54]. Our study is also in consonance with the PA needs and outcomes assessed, and safe PA recommendations that are to be provided by the healthcare practitioners with simultaneous patient education about its benefits and safety [56]. These findings collectively suggest that PA in pregnant and postpartum women is essentially motivated by individual-level considerations, while level alterations in the physical and social settings exert comparatively less influence [57,58].

Implications

Theory-based educational interventions and provider initiatives are necessary to encourage safe PA activity among pregnant and postpartum women. Educational interventions may be implemented in primary care environments, obstetrics and gynecology clinics, resource centers and events, community organizations affiliated with mother and child wellbeing, healthcare organizations pertinent to the diverse practices of the demographics, social media platforms, and targeted mobile health interventions tailored for this subgroup.

MTM can be used as a theoretical framework for designing and assessing educational interventions aimed at improving lifestyle changes, promoting early transition to safe PA in pregnancy and postpartum period, and reducing perinatal morbidity. It emphasizes that physical factors like discomfort and inconvenience can be displaced with behavioral confidence, which can be cultivated through role models and incremental solutions to physical and emotional problems. Physical environment changes can be activated through resource support, while emotional transformation can be used to engage pregnant and postpartum women's emotions towards timely self and baby care. Some implementation strategies involve self-motivation, documentation, reminder systems, family support, mom groups, and alternative strategies of mindfulness. Changes in social environment should be integrated into provider-led educational programs, while encouraging robust policy planning and support for safe PA as a mandatory screening and counselling component for antenatal and perinatal visits.

MTM is a comprehensive modern framework to promote PA among pregnant and postpartum women. The findings demonstrate the explanatory power of MTM constructs, making safe PA in pregnant and postpartum women an evidence-based approach. When creating and assessing PA promotion programs, MTM constructs must be reified, and the psychometrically validated scale developed in this study may be used to evaluate PA promotion programs based on MTM. Furthermore, although the emphasis was on a certain behavior of pregnant or postpartum women living in a southwestern state in USA, the sample demographics aligned with those of the women primarily White, middle-income, and educated, which may have resulted in increased motivation to adhere to the recommendations of safe PA. Further studies are required to evaluate this strategy in a more heterogeneous cohort of pregnant and postpartum women with lack of PA. Finally, alterations to the interventions delivered by healthcare providers (e.g., remote synchronous or asynchronous delivery, mHealth, tailored and segmented programs) are necessary to enhance scalability and

extend access to pregnant and postpartum women living in communities distant from urban areas or provider networks [59-63].

Strengths and limitations

This study is one of the few that utilizes a behavioral theory to identify the determinants of safe PA behavior among pregnant postpartum women as a unique population. This pilot research gathered data from a local representative, appropriately powered sample encompassing a specific subgroup of women aged 18 years and older. The research employed a modern fourth-generation framework of MTM. The psychometric validation of the instrument employed in the study was conducted methodically to explore the underlying factors related to physical activity.

Nonetheless, this study also has certain limitations. Self-reports were employed to gather data regarding minutes of PA performed. Utilization of robust, objective data from PA apps, journaling, and medical records could have enhanced accuracy. The cross-sectional approach and insufficient power restricted the causal inferences, as data on independent factors (MTM constructs) and dependent variables (intentions) are gathered simultaneously. Future study should investigate longitudinal designs. Another limitation is the EFA which only presented correlations among variables and determined the causal relationships between the factors and the observed variables of PA. Understanding the EFA results from this study, we will explore the theoretical model of MTM to rigorously test its pre-defined constructs for PA by confirmatory factor analysis (CFA) in our next study.

CONCLUSIONS

Empirical data is continuously supporting the successful implementation of the fourth-generation, MTM behavioral theory. Among the newly conducted studies supporting MTM is this study that shows that about 46.4% of pregnant or postpartum women sampled had performed some sort of safe PA ≥ 150 minutes per the recommendations in the past week. It is therefore inferred that MTM-based educational and provider-led interventions might help pregnant postpartum women—especially those between the ages of 25 and 35 years—in following safe PA guidelines, hence reducing the inequalities for this unique subgroup within the U.S. population.

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