Original Article

Ecological Model of Adaptation with Diabetes type 2: Development and Study of Empiric Fitness

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Abstract

Introduction: The present study aimed at presenting and testing a model to describe the adaptation phenomenon among the patients engaged with type 2 diabetes (T2D).
Methods: This is a correlational research design wherein a total of 350 individuals referring to four special medical centers for diabetes at Tehran (Iran). The research instruments included the Jackson's five-factor questionnaire, demographic and social support subscales of diabetes care profile, cognitive appraisal of diabetes scale, problem areas in diabetes survey, Billings and Moos coping strategies scale, appraisal of adaptation to diabetes scale, and HbA1C level.
Results: The outputs of the tests on the final model of the research showed that the behavior activating system, fight, flight and freeze system, global social support, and "Get" social support impose significant effects on the cognitive appraisal. Moreover, the "Get-Want" & Global Social support, Fight, Flight & freeze System and the cognitive appraisal affected the adaptive tasks significantly. The Fight, Flight & freeze System and the adaptive tasks imposed significant effects on the problem-focused emotional-physical coping. The Problem focused socio-cognitive coping and the emotional-physical coping affected the initial adaptation significantly. Behavior inhibition system, all the three components of social support, and Problem focused Socio-cognitive coping imposed significant effects on the secondary adaptation. And finally, Global social support and initial adaptation affected the HbA1C significantly. In addition, a number of intermediate effects were verified.
Conclusion: Upon accessing the model of adaptation to disease for a particular individual, one can access his/her adaptation profile and evaluate the strengths and weaknesses of his/her adaptation structure and formulate the required interventions accordingly.

Declaration of Interest: None

Key words: Adaptation, Structural equation modeling, Ecological model, Type 2 diabetes.

Introduction

Research on adjustment with chronic disease is critical in today's world, in which people are living longer lives, but lives are increasingly likely to be characterized by one or more chronic illnesses. Chronic illnesses may deteriorate, enter remission, or fluctuate, but their defining characteristic is that they persist (1). The latest estimates show a global prevalence of 382 million people with diabetes in 2013, expected to rise to 592 million by 2035 (2). Both forms of diabetes can lead to multisystem complications of microvascular endpoints, including retinopathy, nephropathy and neuropathy, and macrovascular endpoints including ischemic heart disease, stroke and peripheral vascular disease. The premature morbidity, mortality, reduced life expectancy and financial and other costs of diabetes make it an important public health condition (2). After the diagnosis of chronic illness such as diabetes, patients are confronted with new situations that challenge their habitual coping strategies and go through a process of psychosocial adjustment (3). Living with diabetes mellitus has been described as a dynamic personal transitional adaptation, based on restructuring of the illness perceived experience and management of the self (4). Given the importance of adaptation to chronic diseases, prediction and possible interventions in the same time or future are necessary in the adaptation phenomenon; this is only possible by providing a pattern or model for adaptation. Following modeling for a phenomenon, in addition to the theoretical simulation, it is possible to quantitatively measure the importance of communication and assess the impact of multiple relationships and consequent interventions.

During the past 30 years, the development of psychosocial adjustment models with chronic disease has been much faster than a simple linear pattern. Many patterns and models have been developed to explain adjustment that can be categorized into four categories, which also show their evolutionary process: Unidimensional, Linear Models, Pendular Models, Interactive Models, and finally Ecological Models (5), which are designed to cover the shortcomings of previous models and not only have the ability to explain previous theories, but also have a broader perspective and have more rigorous empirical support, the model of the Moose and the Holahan are in this range. This model introduces five factors or panels that, in addition to the sequence have interconnected and interactive relationships that correlate with appropriate coping skills and subsequently adaptation.

It can be reasoned that the model proposed by Moos *et al.* combines (6) the rehabilitation approach originated from the grounded theory with the findings of experimental studies to understand the adaptation to a chronic disease as a crisis. This model is clinically advantageous and provides the rehabilitation psychologists with a generative basis on which they can work with a wide variety of the patients with chronic diseases (5).

The basis of all major personality traits is composed of the fundamental motivation systems of avoidance and approach (7). Individuals may either avoid or show tendency towards (or simply do nothing about) probable consequences and this is what is exposed in the form of cognitive patterns and behavior, which is collectively referred to as personality (7). Given the considered concept of adaptation that pursues the improvement of both the psychological and biological consequences, a bio model of personality can better explain and trace the considered relationship in this model. The Gray’s model and the reinforcement sensitivity theory are relevant not only in this respect, but also in that those consider various temperaments, providing them with some explanatory power (7).

Based on the evidences explored in this research, there is a significant difference to the model proposed by Moos and Holahan; direct impact of personal resources on the adaptation regardless of the health-dependent factors and physical and especially social backgrounds; this has been suggested based on the findings of such researchers as Hall (8), and Gois (9).

The health-dependent factors represent the second class of factors incorporated into the model proposed by Moos and Holahan (6). Investigating the adaptation phenomenon, disease-dependent factors are usually known as exogenous variables. Many of the studies focusing on the possible association of adaptation with the disease-dependent factors have ended up finding no significant relationship between the adaptation and such factors (10).

The social factors constitute the third group of initial factors for the adaptation model (11). In the studies performed on the social and physical backgrounds, some type of association and direct effect on the adaptation has been observed, which not only is in agreement with the model proposed by Mouse and Holahan (6), but also somewhat completes the Model (12, 13, 14). Many researchers believe that the effect of stressful events on the wellbeing of the patients with chronic diseases depends on the way such events are appraised (15). The perceived social support serves as a complete mediator between the optimistic personality type and active coping style (16). Higher levels of distress are known to accompany with worse clinical and psychosocial consequences, and shall be considered as a patient-focused index (17,18, 19, 20).

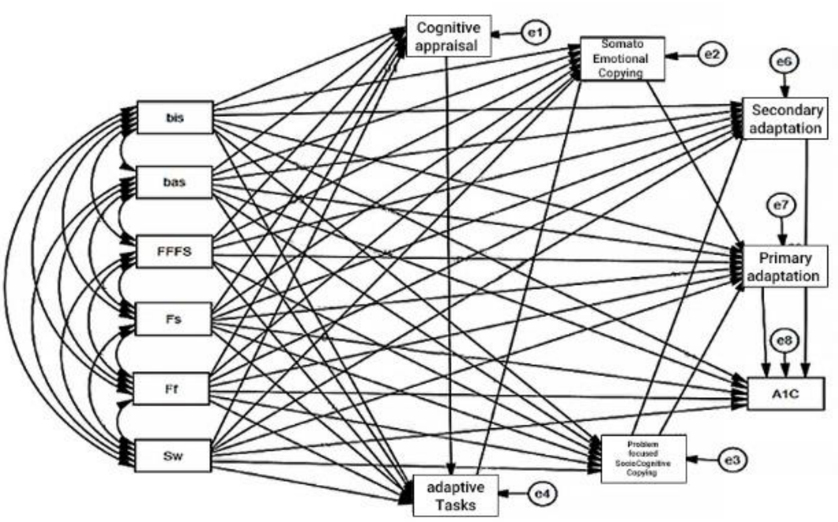
The concept of adaptive tasks refers to the disease-dependent stressors that include the mental appraisal of the disease-caused needs as well as implications for the methods for interacting with these stressors. With this definition, the adaptive tasks falls within the stress-coping interactive framework proposed by Lazaros and Folkman (21), which describes the demand appraisal stressor in a special situation based on inclusion of threat or challenge for personal concerns (22). The idea of personal concerns, which lies within the scope of adaptive tasks, implies a direct relationship to the personal goals, which seem to be strongly linked to the self-adjustment coping theories (22).

The process of coping in response to the person's appraisal begins when major goals are at risk, missed, or threatened (10). The coping is a complex and multidimensional phenomenon which is associated with not only the environment, desires, and resources, but also the personality traits affecting the appraisal of the stress (here the chronic disease) and also available resources for coping (10). Among the patients engaged with the type 2 diabetes (T2D), the neuroticism and psychosis factors and the coping strategies can be considered as important antecedents for self-caring. Compared to emotion-based strategies, the problem-solving-based strategies have ended up with relatively better outcomes for the patients with T2D (22). The differences between the patients with T2D and those without such disease have been significant in terms of the perceived stress, coping strategies, and psychological wellbeing (23).

The present models are general and to address the entire set of chronic diseases; these are conceptual models which, despite the fact that their basis is on valid research observations, are yet to be exposed to experimental testing. That is, as of present, there is no special ecological model for adaptation to diabetes.

Given the review presented above, the present research was aimed at fitting the adaptation to disease model proposed by Mouse and Holahan (6) among the patients engaged with T2D.

Figure 1. Proposed ecological model of adaptation to T2D.



BIS: behavior inhibition system
BAS: behavior activating system
FFFS: Fight, Flight & freeze System
FS: (GET-WANT) social support
SW: (GET) social support
A1C: Hemoglobin A1C

Method

The present research was a correlational study performed via the path analysis method, with the hypothetical model tested using the data obtained from the model variables and the structural equation modeling in the Lisrel

Software followed by analysis using the partial least squares (PLS) method. The statistical population targeted in this research included all patients engaged with the T2D, and the studied sample included a number of patients with T2D referring to some of the medical centers at Tehran, Iran. The inclusion criteria were as follows:

1. Engagement with T2D as per the medical records, with at least six months left from the diagnosis of the disease;
2. A minimum age of 18; and
3. Reading and writing literacy.

The only exclusion criterion considered in this study was possible engagement with physical, psychological, or any other chronic disorder (except for blood pressure disorders, hyperlipidemia, and obesity, which have usually comorbidity with the diabetes). Based on the analyses performed by Hair et al (24) about the required sample size in the structural equation models, which suggest a sample size of 300 for factorial models of 7 or less constructs and low commonalities, a total of 350 patients with T2D referring to several medical centers at Tehran were selected for this study via convince sampling. The centers included T2D Specialty Clinic at Endocrinology and Metabolism Research Institute of Tehran University of Medical Science, Taban Diabetes Specialty Polyclinic, Sa'adat Abad Health Center, and Ghadir-Khom Clinic. The research questionnaires were completed by the participants via self-declaring in interviews. The following questionnaires were used to collect the required data for this research:

Jackson's five-factor questionnaire (Persian-translated): Composed of 30 items; this questionnaire was prepared by Jackson to measure the revised reinforcement sensitivity theory (r-RST) appropriately. It is made up of five subscales: behavioral activation system (BAS), behavioral inhibition system (BIS), and fight-flight-freeze system (FFFS). In Iran, Hasani *et al.* (25) investigated the validity and reliability of the Persian-translated version of this instrument. The obtained ranges of Cronbach's alpha (0.72 – 0.88), test-retest coefficients (0.64 – 0.78), and overall correlation coefficients (0.28 – 0.68) indicated adequate validity of the Persian-translated version of the Jackson's five-factor questionnaire. Confirmatory and exploratory factorial analyses further supported the main five-factor model of the questionnaire. Internal associations among the subscales were appropriate (0.11 – 0.53). Finally, the presence of particular patterns of correlation coefficients between the subscales of the questionnaire, in one hand, and positive emotion, negative emotion, behavioral inhibition/activation systems scales, Eysenck's personality dimensions, and Bart's aggression dimensions, on the other hand, indicated good reliability of the scale.

Demographic and social support subscales of diabetes care profile (DCP): DCP is a common scale for measuring the diabetes-dependent self-caring and quality of life (26). The social support subscale is composed of three scales, namely obtained social support (SW), global social support (FS), and get-want social support (FF). Previous studies support internal stability and constructional and simultaneous validity of many of the DCP scales including the social support. In the initial codification study, internal stability of the support subscale was measured at 0.69 and 0.73 in a sample under social care and a sample selected from an academic medical center, respectively (27). This scale is made up of several subscales: overall social support, desired social support, and existing (received) social support. In a validation study by Yanover and Sacco (27) , the test-retest validity of the three subscales was found to range between 0.38 and 0.48 for an average interval of 6.5 months, which supports acceptable long-term validity of the scales.

Appraisal of diabetes scale (ADS): This is a brief self-reporting 7-item scale that is designed to measure the individual's appraisal of his/her diabetes (28). Internal stability of this scale has been measured as a Cronbach's alpha of 0.73, as per the analysis of principal components. Pearson's product-moment correlation coefficient of the test-retest data shows that the ADS remained stable for both one-hour and one-weak test-retests. Validation of the correlation analysis of the ADS compared to similar questionnaires indicate a moderate to strong association. ADS has been moderately correlated to HbA1C. In total, the ADS scores showed good correlation to the scales of psychological adaptation and current stress, while showing moderate correlation coefficients to the health beliefs and perceived susceptibility to and consequences of diabetes.

Problem areas in diabetes survey (IR-PAID-20): This questionnaire is principally a screening instrument for clinical and research purposes, and helps the clinicians detect the patients experiencing high levels of diabetes-related distress (29). The Cronbach's alpha of the original version of this questionnaire has been 0.95, indicating high internal validity of the instrument. Correlation of each item to the entire questionnaire was good, as per the correlation coefficients in the range of 0.32 – 0.84 (0.68 on average). Simultaneous validity of the questionnaire was investigated and confirmed versus standard questionnaires. Arzaghi *et al.* studied the validity and reliability of the Persian-translated version of this questionnaire, confirming its validity with a Cronbach's alpha of 0.94 and a test-retest score of 0.88 (30).

Billings and Moos coping strategies scale: This scale measures the way individuals respond to stressful events. Five coping strategies are delineated in this questionnaire: cognitive appraisal-focused coping, emotion-focused coping, social support attraction-focused coping, and body inhibition-focused coping or what is referred to as somatization. The test-retest reliability of the Persian-translated version of the scale has been reported as 0.79, while the corresponding value to the problem-solving subscale, emotion-focused coping, cognitive appraisal-focused coping, somatization-focused coping, and social support attraction-focused coping were found to be 0.90, 0.65, 0.68, 0.90, and 0.90, respectively. Internal consistency validity of this questionnaire has been reported to range from 0.41 to 0.66 (31).

In order to investigate the dimensional structure of the questionnaire, principal component analysis with varimax rotation was used. Results of the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy (KMO = 0.76) and the Bartlett's test for sphericity (Chi-square = 2301.98, $p < 0.001$), which were performed to investigate the adequacy of the correlation, were within the desired ranges. Moreover, the results led to the extraction of two factors in this scale that could describe 52% of the observed variance. All of the extracted factorial charges were higher than 0.31. The first factor, which was contained in the questions 10, 12, 13, 14, 15, 17, 19, 25, 28, and 32 of the questionnaire, could be referred to as "Somatoemotional" coping, while the second factor, which was contained in the questions 1, 3, 4, 5, 6, 8, 9, and 11 was called "problem-focused cognitive-social" coping. Investigating the validity of the questionnaire, significant correlation coefficients were observed between the IR-PAID-20 and the Somatoemotional coping (r = 0.42**) and the Problem focused Sociocognitive Coping (r = -0.16**). Moreover, internal consistency validation showed Cronbach's alphas of 0.82 and 0.74 for the Somatoemotional coping and the problem-oriented cognitive-social coping, respectively.

Diabetes adaptation appraisal scale (DAAS): Ebrahimi *et al.* designed a scale with 43 items and acceptable internal stability (Cronbach's alpha = 0.75, and other values ranging from 0.7 to 0.82 for other components). Content validity was investigated both qualitatively and quantitatively using experts' opinions and CVR (0.59) and CVI (min. 0.79) indices, respectively (3).

In order to investigate the dimensional structure of the questionnaire, principal component analysis with varimax rotation was used. Results of the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy (KMO = 0.82) and the Bartlett's test for sphericity (Chi-square = 2132.88, $p < 0.001$), which were performed to investigate the adequacy of the correlation, were within the desired ranges. Moreover, the results led to the extraction of two factors in this scale that could describe 56% of the observed variance. All of the extracted factorial charges were higher than

0.43. The first factor, which was contained in the questions 14, 16, 17, 18, 19, 21, 22, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 40, 41, and 43 of the questionnaire, could be referred to as "secondary adaptation", while the second factor, which was contained in the questions 1, 2, 6, 8, 9, and 12 was called "initial adaptation". Investigating the validity of the questionnaire, significant correlation coefficients were observed between the IR-PAID-20 and the initial adaptation (r = 0.17**) and the secondary adaptation (r = 0.15**). Moreover, internal consistency validation showed Cronbach's alphas of 0.63 and 0.85 for the initial adaptation and secondary adaptation, respectively.

Glycosilated hemoglobin (HbA1C): Concentration of Glycosylated hemoglobin serves as a "record sheet of the blood sugar level" during the past 120 days (average lifetime of the red globules) and provides important information about the recent average blood sugar control. As such, it is known as an inseparable part of administrating the patients with diabetes, where it is used as a tool to monitor the blood sugar control in long run and assess the risk of development of the diseases consequences.

In the present descriptive research, using the data obtained on the model variables and the structural equation modeling, the hypothetical model of the research was tested. Lisrel and SPSS v. 21 were used to analyze the collected data.

Results

Findings of the present research are presented in three parts. We begin with presenting the demographic indices and proceed to present the results obtained from testing the path analysis model of the research as well as the final modified model. As a final part, the intermediate impacts are evaluated.

From the entire pool of the participants of this research, a total of 137 individuals (41.1%) were women while 195 individuals (58.6%) were men. In terms of age, the participants ranged from 23 to 92, with a mean age and standard deviation of 55.67 and 9.52, respectively. In terms of weight, the participants weighed in the range of 45 – 149 kg, with a mean age and standard deviation of 76.94 and 3.04 kg, respectively. A majority of the participants were married (54.1) while some 33.6% of them were divorced. In terms of housing, 71.8% of the participants lived in their private properties, while 23.7% of them were tenants. In terms of education level, the largest group of the participants had no more than a high-school diploma (26.4%), followed by those who had succeeded to obtain a bachelors' degree (23.4%), an elementary school diploma or lower degrees (17.7%), a post-graduate degree (12.9%), any academic certificate (10.5%), and high-school certificates (6.9%). Focusing on the employment status, 26.7% of the participants were housewives, 17.7% of them had full-time jobs, and 16.5% of them were retired. A total of 275 participants (82.6%) enjoyed some basic medical care insurance coverage while 6 participants (1.8%) were protected by no basic medical care plan. Moreover, 186 participants (54.1%) had complementary insurance coverages, while 53 participants (15.9%) were deprived of such a coverage. Regarding preserving records of blood sugar measurements by the patient, the results indicated that 124 participants (37.2%) had not preserved their blood sugar measurement records, while 109 participants (32.7%) declared that they regularly preserve their records of blood sugar measurement. Investigating the person from whom the patient had received the largest support for caring himself/herself, it was found that the largest supports were received from the spouses (43.8%), other members of the family (19.5%), and the doctor (19.2%).

Table 1. Descriptive statistics of the research variables (n=33).

Variable	Mean	Standard deviation	Skewness

A1C	8.04	1.99	0.76
Initial adaptation	17.77	4.57	0.04
Secondary adaptation	87.48	10.30	-0.51
Somatoemotional	12.78	6.22	0.19
Problem-focused emotional-social coping	14.02	4.32	0.18
Adaptive tasks	24.10	14.24	0.19
Cognitive appraisal	17.11	3.61	-0.37
FS	18.81	8.57	0.44
FF	18.66	4.64	0.95
SW	15.17	8.54	0.11
BAS	20.91	3.25	-0.32
BIS	23.48	3.69	-0.58
FFFS	48.21	9.27	-0.23

In order to investigate the causal modeling assumptions, the following methodologies were used:

Missed data: Among the total of 350 participants of the research, the questionnaires from 9 individuals whose data was largely missed were omitted and the questionnaires from the remaining 341 participants were considered for the analysis.

Single-variable and multi-variate outliers: The single-variable outliers on the tangible variables were detected using the frequency tables and box plots, while the multivariate outliers were evaluated using the Mahalanobis distance for each individual. Finally, out of the 341 participants included in the analysis, 8 participants were omitted and the remaining 333 participants were considered as the final sample for detailed analysis.

Sample size determination: According to Kline (32), the minimum required sample size for causal modeling is 200. However, for the purpose of the present research, given the characteristics of the research sample and the number of variables, data was collected from 350 participants. Nevertheless, upon missed data administration and outlier omission, the sample size reduced to 333.

Single-variable normality: In order to evaluate single-variable normality, we began with applying the Kolmogorov-Smirnov test followed by calculating the skewness and kurtosis for each variable. Results of the Kolmogorov-Smirnov test (Table 2) were significant for all of the research variables ($p < 0.05$). Accordingly, continuing with investigating the normality of the data, the skewness and kurtosis were calculated for each variable. According to the results reported in Table 1, the variables exhibited skewness and kurtosis values in the ranges of – 0.95 to 0.76 and -1.11 to 0.94, respectively. All by all, the obtained values of skewness and kurtosis for the research variables implied that the variables of the present research exhibit some near-normal distribution.

Multivariate normality: Although the multivariate normality investigation is difficult to do in practice, particular strategies have been proposed for such a purpose. In the present paper, the multivariate normality assumption was investigated by calculating the relative multivariate kurtosis, returning a value of 1.031. According to Bentler (33), multivariate normality can be confirmed if the value of the relative multivariate kurtosis falls below 3.

Multicollinearity: A common method for investigating the multicollinearity is to explore the matrix of the correlations of the variables. Accordingly, the correlation coefficients exceeding 0.85 produce problems for estimating the model by generating multicollinear problems (32). In this research, the correlation coefficients were found to

range from -0.06 to 0.52**, confirming the absence of multicollinearity.

Table 2. Results of Kolmogorov-Smirnov test for evaluating the normality hypothesis.

Scale	Test statistic	Degree of freedom	Significance
A1C	0.14	333	0.001
Initial adaptation	0.07	333	0.001
Secondary adaptation	0.06	333	0.017
Somatoemotional coping	0.08	333	0.001
Problem-focused emotional-social coping	0.08	333	0.001
Adaptive tasks	0.06	333	0.003
Cognitive appraisal	0.09	333	0.001
FS	0.12	333	0.001
FF	0.12	333	0.001
SW	0.13	333	0.001
BAS	0.10	333	0.001
BIS	0.09	333	0.001
FFFS	0.05	333	0.024

Once finished with investigating the assumptions, the research data was screened and the hypotheses of the path analysis model were formulated. Subsequently, the fitness of the path analysis model and the research hypotheses were tested. The model fitness results are presented in Table 3 and the results of testing the research hypotheses are given in Figure 2 (standardized path coefficients) and Table 4.

As can be observed from Table 3, given the obtained values of χ^2 and particularly the RMSEA, the results of fitness of the hypothetical path analysis model indicated relatively undesirable fitness of the model per most of the fitness indices. Therefore, the initial model was found to be inefficient in terms of fitness and required modifications.

Table 3. Fitness indices of the path analysis model (initial hypothetical model).

Fitness index	Acceptable range	Value
Chi-squared (χ^2)	-	80.80
χ^2-to-DOF ratio	Lower than 3	5.38
Normalized fitness index (NFI)	Higher than 0.90	0.90
Confirmatory fitness index (CFI)	Higher than 0.90	0.91
Incremental fitness index (IFI)	Higher than 0.90	0.92
Goodness-of-fit index (GFI)	Higher than 0.90	0.96
Root mean square error of approximation (RMSEA)	Lower than 0.08	0.12

Figure 2 and Table 4 show the standardized coefficients of the initial hypothetical path analysis model. As can be observed, BAS (with a path coefficient of 0.14) and FFFS (with a path coefficient of 0.28) impose significant impacts on the cognitive appraisal. Moreover, FF, FS, FFFS, and cognitive appraisal imposed significant impacts on the adaptive tasks, as per the path coefficients of 0.10, -0.14, 0.11, and 0.57, respectively. With path coefficients of 0.33 and 0.36, respectively, FFFS and adaptive tasks were found to affect the Somato-emotional coping significantly. Effects of BAS, FFFS, and FF on the Problem focused Socio-cognitive Coping were significant at path coefficients of 0.17, -0.15, and 0.17, respectively. In addition, FF, SW, FS, and Problem focused Socio-cognitive Coping imposed significant impacts on the secondary adaptation at path coefficients of -012, -0.16, 0.15, and 0.35, respectively, while the Somato-emotional coping and Problem focused Socio-cognitive Coping were found to significantly affect the initial adaptation at path coefficients of 0.12 and -0.21, respectively. Finally, the initial adaptation was found to impose significant impacts on the A1C at a path coefficient of 0.24. The other path coefficients across the initial model of the research showed no significant effect.

Figure 2. Path analysis model of the research with standardized coefficients.

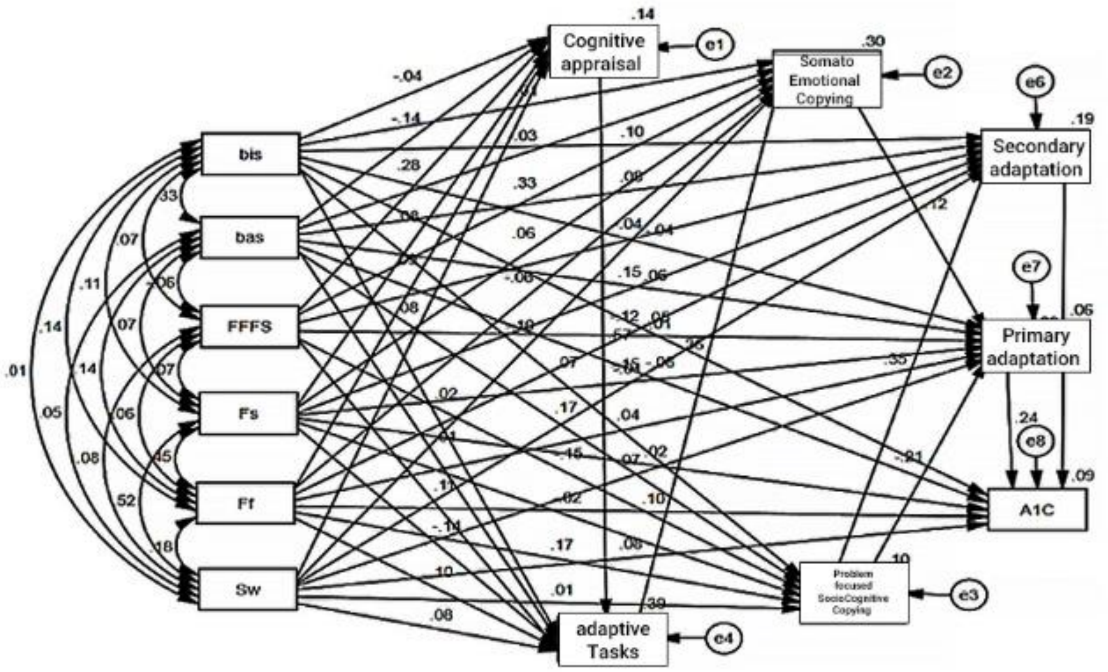


Table 3. Standardized path coefficients of the hypothetical model with calculated significance levels.

Path	→	Standardized coefficients	Significance level
BIS	Cognitive appraisal	-0.038	0.485
BAS	Cognitive appraisal	-0.136	0.012
SW	Cognitive appraisal	0.081	0.177
FF	Cognitive appraisal	0.092	0.111
FS	Cognitive appraisal	0.78	0.234
FFFS	Cognitive appraisal	0.278	0.001
SW	Adaptive tasks	0.075	0.135
FF	Adaptive tasks	0.104	0.032
FS	Adaptive tasks	-0.137	0.013
FFFS	Adaptive tasks	0.109	0.016
BIS	Adaptive tasks	0.020	0.667
BAS	Adaptive tasks	0.008	0.870
Cognitive appraisal	Adaptive tasks	0.572	0.001
FFFS	Somatoemotional coping	0.333	0.001
FF	Somatoemotional coping	-0.059	0.257
BAS	Somatoemotional coping	-0.027	0.588
BIS	Somatoemotional coping	0.008	0.869

FS	Somatoemotional coping	0.064	0.281
SW	Somatoemotional coping	-0.098	0.070
Adaptive tasks	Somatoemotional coping	0.358	0.001
BAS	Problem focused SocioCognitive Coping	0.172	0.002
FFFS	Problem focused SocioCognitive Coping	-0.152	0.004
FF	Problem focused SocioCognitive Coping	0.171	0.004
SW	Problem focused SocioCognitive Coping	0.007	0.913
FS	Problem focused SocioCognitive Coping	-0.020	0.766
BIS	Problem focused SocioCognitive Coping	0.070	0.209
BIS	Secondary adaptation	0.101	0.057
FF	Secondary adaptation	-0.120	0.034
FFFS	Secondary adaptation	-0.036	0.474
BAS	Secondary adaptation	0.079	0.140
SW	Secondary adaptation	-0.155	0.008
FS	Secondary adaptation	0.150	0.019
Problem focused Sociocognitive coping	Secondary adaptation	0.352	0.001
BAS	Initial adaptation	0.057	0.327
FFFS	Initial adaptation	-0.013	0.830
FF	Initial adaptation	0.042	0.485
BIS	Initial adaptation	-0.043	0.451
SW	Initial adaptation	0.074	0.241
FS	Initial adaptation	-0.008	0.906
Problem focused Sociocognitive coping	Initial adaptation	-0.211	0.001
Somatoemotional coping	Initial adaptation	0.118	0.046
FF	A1C	0.103	0.083
SW	A1C	0.083	0.182
BAS	A1C	-0.078	0.168
BIS	A1C	0.048	0.390
FS	A1C	0.020	0.771
Secondary coping	A1C	0.239	0.629
Initial coping	A1C	-0.026	0.001

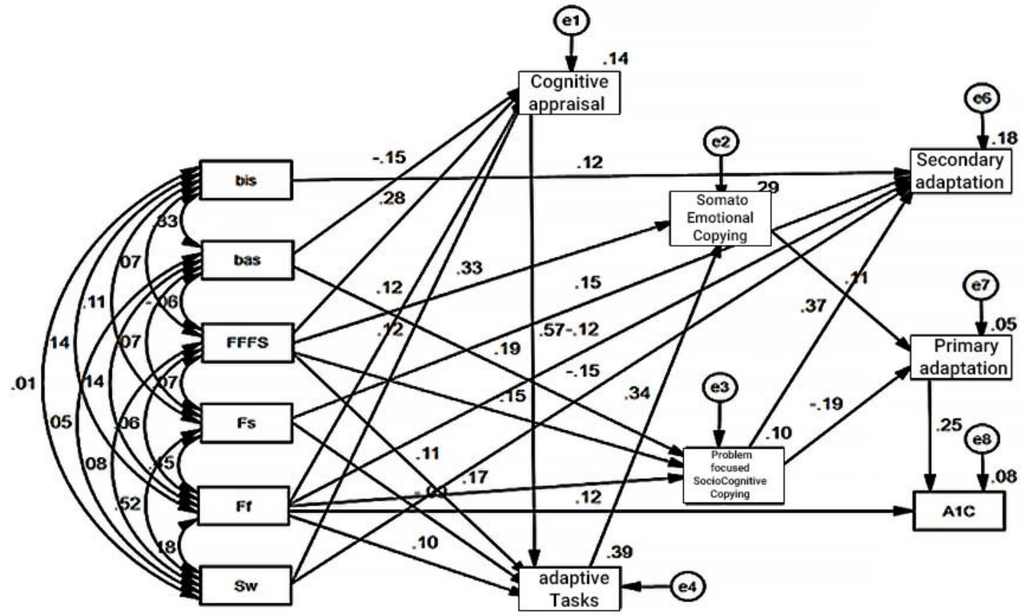
Considering the inappropriate fitness of the model and the fact that some of the paths were insignificant, these paths were adjusted and the model was reevaluated to calculate the path coefficients and determine the model fitness. Table 5 shows the fitness indices of the final model and Figure 2 demonstrates the standardized coefficients of the final path analysis model. The obtained values of the fitness indices on the final model indicate satisfactory fitness of the model.

Table 4. Fitness indices of the final model.

Fitness index	Acceptable range	Value

Chi-squared (χ^2)	-	103.81
χ^2-to-DOF ratio	Lower than 3	2.53
Normalized fitness index (NFI)	Higher than 0.90	0.87
Confirmatory fitness index (CFI)	Higher than 0.90	0.92
Incremental fitness index (IFI)	Higher than 0.90	0.92
Goodness-of-fit index (GFI)	Higher than 0.90	0.96
Root mean square error of approximation (RMSEA)	Lower than 0.08	0.068

Figure 3. The final path analysis model with standardized coefficients.



Results of testing the final model of the research indicated significant impacts of BAS, FFFS, FF, and SW on the cognitive appraisal at standardized coefficients of -0.15, 0.28, 0.12, and 12, respectively. Moreover, FS, FF, FFFS, and cognitive appraisal affected the adaptive tasks significantly at standardized path coefficients of -0.10, 0.10, 0.11, and 0.57, respectively. The Somatoemotional coping was found to be significantly associated with FFFS and adaptive tasks at standardized path coefficients of 0.33 and 0.34, respectively. The effects of BAS, FFFS, and FF on the Problem focused Sociocognitive coping were significant at standardized path coefficients of 0.19, -0.15, and 0.17, respectively. The Problem focused Sociocognitive coping and Somatoemotional coping imposed significant effects on the initial adaptation at standardized path coefficients of -0.19 and 0.11, respectively. The secondary adaptation was found to be significantly associated with the BIS, FF, FS, SW, and Problem focused Sociocognitive Coping at standardized path coefficients of 0.12, -0.12, 0.15, -0.15, and 0.37, respectively. Finally, significance of the effect of FF and initial adaptation on the A1C was confirmed at standardized path coefficients of 0.12 and 0.25, respectively.

Table 5. Standardized path coefficients of the final research model with calculated significance levels.

Path		Standardized coefficients	Significance level
BAS →	Cognitive appraisal	-0.149	0.004

FFFS	Cognitive appraisal	0.277	0.001
FF	Cognitive appraisal	0.116	0.027
SW	Cognitive appraisal	0.117	0.024
FS	Adaptive tasks	-0.096	0.049
FF	Adaptive tasks	0.102	0.033
FFFS	Adaptive tasks	0.112	0.013
Cognitive appraisal	Adaptive tasks	0.573	0.001
FFFS	Somatoemotional coping	0.333	0.001
Adaptive tasks	Somatoemotional coping	0.34	0.001
BAS	Problem-focused cognitive social coping	0.194	0.001
FFFS	Problem-focused cognitive social coping	-0.147	0.005
FF	Problem-focused cognitive social coping	0.169	0.001
Problem-focused cognitive social coping	Initial adaptation	0.001	-0.194
Somatoemotional coping	Initial adaptation	0.042	0.109
BIS	Secondary adaptation	0.016	0.122
FF	Secondary adaptation	0.039	-0.117
FS	Secondary adaptation	0.022	0.148
SW	Secondary adaptation	0.009	-0.154
Problem-focused cognitive social coping	Secondary adaptation	0.001	0.373
FF	A1C	0.020	0.123
Initial adaptation	A1C	0.001	0.251

In this research, the bootstrap test was used to evaluate indirect intermediary associations. The significance of such associations can be examined via either of two procedures. The first procedure focuses on the significance levels while the second procedure is based on confidence intervals. Accordingly, if the upper and lower bounds for a particular intermediary path are of the same sign (*i.e.* both are either positive or negative) within the 95% confidence interval, which means that no zero value occurs in between the two bounds, the considered path is recognized as significant at $p < 0.05$ significance level. Results of testing the intermediary associations are presented in Table 6.

Table 6. Results of the bootstrap test for examining the intermediary associations.

Intermediary paths		Standardized path coefficient	Bootstrap bounds		Significance level	Results of intermediary path test
	→		Lower	Upper		
SW	Adaptation tasks	0.067	0.003	0.136	0.041	Confirmed
FF	Adaptive tasks	0.067	0.014	0.120	0.013	Confirmed
FFFS	Adaptive tasks	0.158	0.101	0.221	0.001	Confirmed
BAS	Adaptive tasks	-0.085	-0.141	-0.028	0.002	Confirmed
SW	Somatoemotional coping	0.023	0.002	0.051	0.035	Confirmed
FF	Somatoemotional coping	0.058	0.022	0.102	0.001	Confirmed
FFFS	Somatoemotional coping	0.093	0.057	0.140	0.001	Confirmed

FS	Somatoemotional coping	-0.033	-0.071	-0.002	0.036	Confirmed
BAS	Somatoemotional coping	-0.029	-0.051	0.010	0.001	Confirmed
Cognitive appraisal	Somatoemotional coping	0.197	0.138	0.262	0.001	Confirmed
SW	Initial adaptation	0.003	0.001	0.009	0.053	Rejected
FF	Initial adaptation	-0.027	-0.062	-0.003	0.029	Confirmed
FFFS	Initial adaptation	0.075	0.021	0.137	0.006	Confirmed
FS	Initial adaptation	-0.004	-0.012	0.001	0.052	Rejected
BAS	Initial adaptation	-0.041	-0.076	-0.017	0.001	Confirmed
Cognitive appraisal	Initial adaptation	0.021	0.001	0.050	0.051	Rejected
Adaptive tasks	Initial adaptation	0.038	0.001	0.085	0.052	Rejected
FF	Secondary adaptation	0.063	0.023	0.112	0.001	Confirmed
FFFS	Secondary adaptation	-0.055	-0.100	-0.017	0.006	Confirmed
BAS	Secondary adaptation	0.072	0.032	0.120	0.001	Confirmed
SW	A1C	0.001	0.001	0.002	0.045	Confirmed
FF	A1C	-0.007	-0.018	-0.001	0.021	Confirmed
FFFS	A1C	0.019	0.005	0.042	0.004	Confirmed
FS	A1C	-0.001	-0.004	-0..001	0.042	Confirmed
BAS	A1C	-0.010	-0.022	-0.004	0.001	Confirmed
Cognitive appraisal	A1C	0.005	0.001	0.015	0.039	Confirmed
Adaptive tasks	A1C	0.009	0.001	0.025	0.041	Confirmed
Problem focused SocioCognitive Coping	A1C	-0.049	-0.090	-0.019	0.001	Confirmed
Somatoemotional comping	A1C	0.027	0.001	0.068	0.047	Confirmed

Discussion

In the present research, there was not any effect between the BIS and any of the model components except for that between the BIS and secondary adaptation (p = 0.016). Although this finding is seemingly opposing the findings of Hall (7) who suggested that the BIS imposes a direct and inverse intermediary effect on the HbA1C level, but one should notice that he considered the newly diagnosed patients within the early 6 months of engagement with the diseases. Accordingly, the two seemingly opposing findings may actually be complementary to one another. In the Hall study, no association was found between BAS and the level of diabetes-induced distress and ultimately HbA1C, which was not consistent with the present study. But at the same time, this contradiction is in line with other findings of this study, namely that primary adaptation is effective on HbA1C levels but secondary adaptation is not. That is, the Hall study occurred in the primary adaptation condition and this study in the secondary adaptation condition. No studies were found regarding the association between FFFS and diabetes-related distress.

The measured social support has three components, namely obtained support (SW), Get-Want support (FS), and global support (FF). Our findings confirmed the direct effect of SW on cognitive appraisal (p = 0.024) and secondary adaptation (p = 0.009), direct effect of FS on adaptive tasks (p = 0.049) and secondary adaptation (p = 0.022), and direct effect of FF on cognitive appraisal (p = 0.027), adaptive tasks (p = 0.033), Problem focused Socio-cognitive Coping (p = 0.001), secondary adaptation (p = 0.039), and HbA1C. These findings are in agreement with those reported by Pintaudi (17) indicating the inverse association of the perceived distress of diabetes and perceived social support.

The present work confirmed the intermediary effect of the cognitive appraisal on HbA1C (p = 0.039). This is not only in line with the findings of Winchester *et al.* (20) who suggest that the diabetes distress is significantly affected the HbA1C and acts as a more serious risk factor for increasing the HbA1C compared to increased depression symptoms or serious psychological distress, but also in agreement with the findings of Fischer *et al.* (20) who discovered a direct relationship between the diabetes distress and HbA1C in the patients with T2D. The present work showed that there is an intermediary effect of adaptive tasks on the HbA1C (p = 0.041), which is in agreement with the findings of Pintaudi (17) and Co (18) who suggested that the higher the level of distress in the scope of diabetes-caused problems, the weaker will be the blood sugar control. Moreover, the intermediary effect between these two components (intermediated by the self-caring) was identified in Pintaudi's study.

Based on the studies performed in this research, the Somato-emotional coping was found to be directly affected the adaptive tasks (p = 0.001) and intermediary effect on the cognitive appraisal (p = 0.001) via the adaptive tasks, while the Problem focused Socio-cognitive Coping exhibited no effect with either of the above-mentioned scales.

In addition, the Somato-emotional coping was found to have effect on the initial adaptation (p = 0.042) and through that to the HbA1C (p = 0.001), while the Problem focused Socio-cognitive Coping was found to affect not only the initial adaptation (p = 0.001), but also the secondary adaptation (p = 0.001). A comparison between these findings and the previous research works highlights particular complexities to which Burns (34) pointed out. According to cross-sectional research works, the task-focused coping has been found to be inversely related to diabetes-dependent distress (in contrast to the results of the present work), while the emotion-focused coping is directly related to the distress (in agreement with the present work). However, this pattern is not prospectively preserved, that is the task-focused coping may not play any preventive effect (in agreement with the present work) (35) but rather the emotion-focused coping provides such association (in contrast to the present work) according to (Karlsen *et al.*, Smári & Valtýsdóttir, and Tuncay *et al.*) ([35], 36, 37, 38).

The task-oriented coping is associated with moderate to high increase in the probability of the diabetes-related distress when measured simultaneously with mental health state. This is while the task-oriented coping is not associated with such states in the individuals who do not satisfy the criteria of this state at the baseline. The above-described pattern suggests the idea that, there are chances that this is the mental health state that affects the task-oriented coping rather than vice versa. Distress may inhibit the ability of the patients with T2D to adopt the task-focused coping strategies. Moreover, results of the prospective analysis imply that the emotion-focused coping strategy plays an outstanding role in the initiation of moderate to intense diabetes-related distress, and this is in agreement with the hypothesis that the consequences of mental health are more sensitive to the coping strategies that directly affect the affective states (35).

The initial adaptation is directly affected the level of HbA1C (p= 0.001), while no significant effect was found between the secondary adaptation and HbA1C. This finding is of paramount importance and supports the necessity of social-mental prevention prior to the engagement of the individuals susceptible to diabetes or even the entire society given the extensive outbreak of the disease.

The adaptation to the disease leads to improved control of the somatic and psychological symptoms. Among the somatic advantages of this phenomenon, one may refer to the retardation of the physical consequences caused by failure to control the blood sugar level, such as cardiovascular diseases, retinopathy, and kidney disorders, which ends up reducing the rate of fatalities caused by such consequences (7). Stanton *et al.* (10) showed that successful adaption to a chronic disease results in the following outcomes: successful performance of adaptive tasks, suppression of psychological disorders, less experience of negative affections, improved states of wellbeing functions and appraisal in different scopes of life.

The limitations of this study were as follow 1) This was a cross-sectional study in which being cause prior to effect cannot be met and 2) participants were not selected at random, to generalize findings. Of course, the multicenter study have been used to overcome this limitation.

Conclusion

Upon achieving the adaptation to disease model of each person, one can reconstruct his/her adaptation profile and evaluate cons and pros of his//her adaptation structure; this structure can then be used as a basis for designing the required interventions. From the viewpoint of diabetes care system, one can use such a model to evaluate the effectiveness of the model components and prioritize the major programs targeting the adaptation to this disease based on such effectiveness profile, so as to channelize the limited available resources toward the most effective plans. To sum up, as far as mental and social aspects are concerned, the T2D adaptation model and its application contribute to higher quality of life, enhanced mental health, and reduced mental distress. At the same time, biologically speaking, such adaptation helps the patients with T2D achieve improved somatic health, fewer disease-induced complications, and longer life expectancy.

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