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Advanced Predictive Modeling of Sport Commitment Using Machine Learning Among Fitness Center Users in Riyadh

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Abstract: This paper studies the development and testing of advanced statistical and machine learning methods to predict sport commitment using fitness center visitor data; examines how psychological and social factors influence sport commitment; investigates how sport commitment dimensions predict mental health outcomes; and compares the predictive accuracy of traditional statistical models with machine learning approaches. Using a cross-sectional quantitative design, the researchers analyzed data from 423 participants from Riyadh fitness centers. Validated instruments measured self-regulation, sport commitment, and mental health, and correlations, stepwise regression, structural equation modeling (SEM), and Random Forest analysis were used to assess model performance. Results showed that self-regulation significantly predicted sport commitment ($\beta = 0.748$, $p < 0.001$) but did not directly affect mental health. Sport commitment predicted mental health ($\beta = 0.317$, $p < 0.001$) and fully mediated the relationship between self-regulation and mental health. Mastery orientation and emotional support and social factors were among the strongest predictors, and the Random Forest model outperformed linear regression ($R^2 = 0.932$). Overall, sport commitment appears to be the psychological mechanism linking self-regulation and mental health.

Keywords: Sport Commitment; Self-Regulation; Mental Health; Predictive Modeling; Machine Learning; Fitness Centers.

1. Introduction

Sports participation is increasingly recognized as a multidimensional psychological and behavioral activity that requires sustained commitment, self-regulation, and psychological well-being. Contemporary sport psychology research emphasizes that continued participation in physical activity is influenced by motivational, cognitive, and social factors [1]. People show their dedication to sports through their desire to participate while maintaining their mental commitment to the activity despite facing their personal boundaries and financial obligations and their need to fulfill other responsibilities [2, 3]. Also, The SCQ-2 updated [4] the commitment framework and improved psychometric accuracy for sport commitment sources and kinds, The SCQ-2 functioned as a valid and reliable assessment tool for Malaysian researchers studying racquet sports participants who wanted to measure their contemporary athletic dedication, The scale's psychometric robustness makes it valuable for studying how passionate or limited commitment affects prolonged engagement and psychological effects [5]. Furthermore, Athletes use self-regulation skills to develop their plans and assessment methods and performance evaluations which they use to improve their behavior until they reach their objectives. The Sportive Self-Regulation Scale (SSRS) athletic self-regulation abilities in sports [6]. The process of self-regulation enables people to transform their intentions into consistent actions which makes it a crucial factor in difficult sports and goal-driven athletic activities [7]. SSRS functions as a tool to examine athlete patterns of exercise maintenance and their reactions to obstacles together with their ability to sustain mental focus [6, 8, 9].

The connection between self-regulation and sport commitment and mental health functions as a hierarchical psychological system which requires mediation to achieve understanding instead of existing as distinct effects. Self-regulation serves as a fundamental cognitive-behavioral mechanism which assists people in starting and maintaining their athletic activities by means of planning and monitoring and evaluation [10]. Theoretical and empirical evidence suggests that self-regulation alone may not guarantee sustained engagement in sport unless it is supported by stable motivational processes such as sport commitment [11]. Sport commitment represents a motivational mechanism through which regulatory abilities are transformed into long-term behavioral engagement. This process is strengthened by intrinsic motivational factors such as mastery orientation, enjoyment, emotional support, and social relatedness [11-13]. Accordingly, self-regulation may facilitate behavioral initiation, whereas sport commitment supports behavioral persistence and continuity.

In other words, the mediation pathway holds vital importance for understanding mental health results, The psychological advantages which people gain from sports depend on how they engage with sports at various levels of commitment rather than

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how they simply participate in sports [14-15]. To clarify, the mental health of individuals who show strong dedication to sports activities improves because their dedication enables them to maintain their participation while experiencing psychological stability and positive emotions, The psychological benefits of activities will decrease or disappear when people participate in activities because they must do so or because they have no strong internal motivation to do so [13, 16].

The current research has demonstrated that self-regulation acts as an indirect relationship which connects to mental health through sport commitment which serves as a full or partial barrier to the connection [17-18]. Also, the main method through which regulatory abilities affect mental health outcomes occurs through their effects on sustained engagement together with the quality of motivation. The modeling results show that motivational and social variables have better predictive power for behavioral and psychological results than cognitive elements used in isolation according to structural equation modeling and advanced predictive approaches [19-20].

The relationship among self-regulation, sport commitment, and mental health may be conceptualized as an integrated psychological system. Self-regulation contributes to the initiation and management of behavior, sport commitment supports the maintenance of participation over time, and mental health reflects the long-term psychological outcomes associated with sustained engagement in physical activity. This integrated framework provides a broader understanding of sport participation by combining cognitive, motivational, and social dimensions [21-22]. The existing research on self-regulation and sport commitment and mental health shows increasing activity yet significant research gaps still exist. The research has studied these categories separately or through basic bivariate studies but has not developed a complete theoretical framework that shows their connections. The research lacks empirical evidence to support the hypothesis that sport commitment functions as a mediator between self-regulation and mental health [23-24].

Despite the expanding scholarship on self-regulation, sport commitment, and mental health, a few key research voids still linger in the background. Many prior papers looked at these concepts one at a time, or they used mostly straightforward correlational designs, which might not really reflect the intricate and sometimes nonlinear ties among psychological and behavioral elements. Also, the available work has not consistently brought in more advanced analytic tools like structural equation modeling or machine learning in a unified way, so the links are rarely studied side by side. On top of that, contextual evidence, especially from Middle Eastern groups, and more specifically from Saudi Arabia, is still rather sparse. So, the current study tries to bridge these limitations by building an integrated predictive structure, linking self-regulation with sport commitment and mental health, and doing this for fitness center users in Riyadh, while relying on advanced statistical and machine learning techniques.

2. Literature Review

2.1 Self-Regulation

The process of self-regulation functions as a fundamental psychological mechanism which supports people in achieving their objectives while maintaining their performance across different fields of sports competition. [25] defines self-regulation as the personal capacity to create action plans which individuals can use to track their progress while assessing their work to meet their determined objectives. The social cognitive framework defines self-regulation as a process which occurs in three main steps that include forethought, performance, and self-reflection to help people behave consistently while developing their skills .Self-regulation serves as an essential function for athletes because it enables them to keep their training schedule while dealing with various hurdles which they face during their athletic journeys.

The Sportive Self-Regulation Scale (SSRS) developed by [6] operationalizes this construct through three dimensions: planning, implementation, and evaluation. The planning process shows how people establish goals while preparing to achieve them, implementation process represents how people execute their plans while maintaining their dedication to their tasks, and evaluation process enables people to assess their performance through self-evaluation and the application of feedback [26].

Research studies have shown that people who possess better self-regulation skills show more determination to succeed, achieve superior performance results, and remain committed to their sporting activities according to the findings of [27] Self-regulation shows a strong connection to both self-efficacy as well as motivation and adaptive coping strategies which assist people in maintaining their long-term participation in sports .The research findings demonstrate that self-regulation functions as a vital component for maintaining prolonged sport dedication, which requires both motivational and contextual elements to operate effectively. People need motivational and environmental elements to function properly, which shows that self-regulation only acts as a supportive element for their activities [28-29]. The impact of the factor becomes less potent because its effects depend on motivational orientations and social support systems to guide its results, Theoretical explanation defines self-regulation as a concept which supports social cognitive theory because both theories believe that human behavior develops through the interaction of personal factors, behavioral patterns, and environmental factors according to Bandura's research from 1986 [30-31]. The sporting environment demonstrates that people can possess excellent self-control abilities yet their ongoing participation depends on the motivational and social elements which exist in their surrounding environment [32].

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2.2 *Sport Commitment*

Athletic commitment stands as the primary element that scholars use to explain why athletes maintain their sports participation along with their physical activity [33]. The psychological state of an athlete who shows dedication to continuous sport engagement exists as a psychological state which scientists measure through two specific dedication measurement tools [11]. The dedication to sports through sport commitment operates as a long-term factor which people use to maintain their sports practice while short-term motivation operates as a temporary driving force.

Consequently, The Sport Commitment Model serves as an all-encompassing tool which researchers utilize to study the factors that determine athletic dedication [34]. The model shows that multiple elements, which include enjoyment, personal investment, perceived opportunities, social support, and social constraints, determine the level of sport commitment which athletes demonstrate toward their sport activities [35]. The commitment process shows a dual nature because it includes both internal and external factors which people use to establish their level of dedication to sports, The rocess of continuous athletic participation depends most on intrinsic motivation which people gain from mastering new skills and enjoying their sport activities, Mastery orientation describes the human tendency to acquire new abilities through dedicated practice which links to intrinsic motivation and long-term dedication to learning, People strengthen their commitment to sports through emotional and social support which they receive from their peers and coaches and key people in their life [11, 36].

Self-Determination Theory (SDT) stands as the theoretical basis which supports research about sport commitment because this theory states that people will remain dedicated to activities when they meet their three essential psychological needs which include autonomy and competence and relatedness [13, 37]. Mastery orientation enables people to achieve competence whereas emotional and social support functions as a means for people to build social relationships with others. The fulfillment of these requirements leads to intrinsic motivation development which results in greater dedication to work [38]. People may lose their ability to make independent decisions when they face informational pressure and when they experience excessive outside control which leads to lower levels of intrinsic motivation and commitment [39-40]. The study emphasizes that organizations should establish environments which support people to achieve autonomy and foster active participation because people should not depend on external rules to guide their behavior, The concept of sport commitment functions as a vital link which connects all three psychological factors and social factors and behavioral factors to explain how people maintain their sports activity and the resulting effects on their lives.

2.3 Mental Health

The definition of mental health includes three dimensions which show emotional psychological and social functioning. Mental health serves as an essential outcome of continuous physical activity because it receives more recognition from sports organizations [41-43]. The mental health benefits that come from sports participation exist because athletes experience physical changes which lead to chemical changes in their brains and develop psychological traits and establish social connections with others who relate to their experiences [44-45]. Athletes and physically active individuals can use the Sport Mental Health Assessment Tool-1 (SMHAT-1) developed by [17] to test their mental health through a systematic method which uses scientific evidence to assess their mental health condition, The tool provides a complete mental health assessment which examines anxiety depression sleep problems and overall psychological health. The instrument achieved wide usage in sport psychology research because its development received international backing through empirical validation [33, 46].

The research shows that people who maintain an active lifestyle experience better mental health because their physical activity decreases their depression and anxiety symptoms while it boosts their psychological wellness [14, 47-48]. The relationship between sport participation and mental health develops through psychological elements which include motivation and commitment and perceived autonomy according to emerging evidence [15, 49], The framework of Self-Determination Theory (SDT) explains that mental health depends on people achieving three fundamental psychological needs which include autonomy and competence and relatedness [49]. People who participate in sports show higher well-being when they experience self-directed participation and they develop their skills and they build social bonds. People who participate through external control or excessive informational pressure lose their ability to control their time which leads to worse psychological health and more stress [16, 50]. The recent studies show that sport commitment functions as a mediator which connects psychological processes to mental health results. The people who develop strong commitment to sport will keep participating in their sport which brings them happiness and they will feel better emotionally [11, 51-52]. The mental health advantages from participation arise from how people engage with their activities throughout their time in sports.

The distinction between intrinsic and extrinsic motivation determines which mental health results people will experience. People who join activities for intrinsic reasons which bring them joy and the chance to learn new skills and develop themselves will experience better mental health results while those who join activities for external reasons will face stress and burnout and their mental health will decline [53-54]. People who want to understand mental health in sports need to use a multidimensional approach which combines psychological regulation with motivational commitment and social context, The approach shows how sports participation improves mental health while explaining which environmental factors enable people to gain autonomy and competence and form social connections [55-56].

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3. Methods

3.1 Study Design

This study used a quantitative cross-sectional design to investigate how self-regulation and sport commitment and mental health connect with each other among fitness center attendees in Riyadh.

3.2 Sampling and Analysis

The research involved 423 people who were gathered from fitness centers located in Riyadh. Participants were recruited from privately operated fitness centers in Riyadh. These centers generally follow gender-segregated arrangements in accordance with local cultural and organizational practices. The participants included regular membership holders with varying attendance patterns and exercise frequencies.

The sample included 56.3% of male participants who numbered 238, while female participants made up 43.7% with 185. The sample showed nearly equal gender representation because males slightly outnumbered females .The age distribution shows that most participants fell within the 20 to 24-year range, which included 207 people or 48.9% of the total. The second largest age group consisted of 162 people who were younger than 20 years old, while 54 people or 12.8% belonged to the 25 to 27-year age group. The sample contains mainly young adults who fit the pattern of typical gym attendance .The participants reported their fitness center attendance as 38.3% who went once a week, 31.2% who visited three times a week, 16.3% who came twice a week, and 14.2% who visited every day, The attendance pattern suggests varying levels of physical activity, with a substantial proportion of participants attending only once weekly, which may limit the psychological benefits typically associated with regular exercise participation.

The largest educational group in the sample included 44.0% of participants who possessed a bachelor's degree, followed by 32.6% who held a diploma, and 23.4% who achieved postgraduate status. The sample displays high educational attainment . The study found that 61.9% of participants had medium economic status, while 24.6% fell into high economic status and 13.5% belonged to low economic status. The study population showed that middle-income individuals made up the largest group of participants. Figure 1 provides a comprehensive visual representation of the demographic composition of the study sample, highlighting variability across key demographic characteristics.

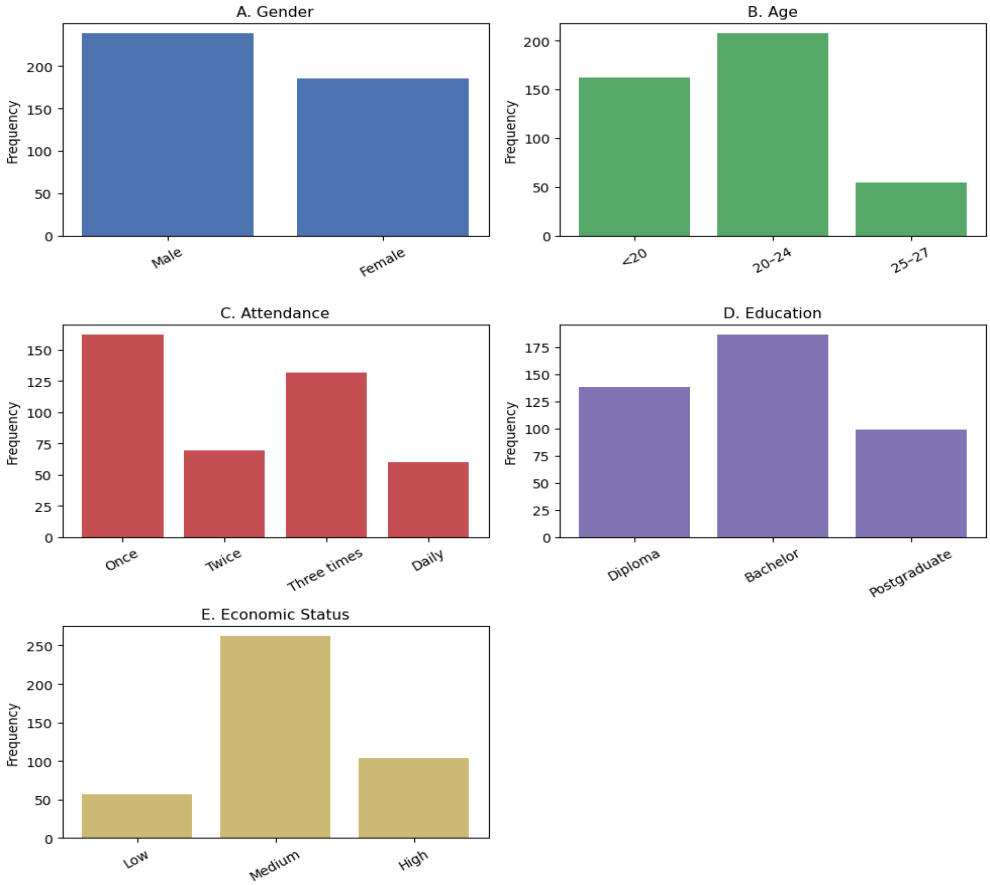

Fig. 1: Demographic profile of the study sample N = 423

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3.3 Measurement

The research utilized a structured questionnaire which contained three standardized instruments for measuring self-regulation and sport commitment and mental health. The study used Likert-type response format for all scales which allowed higher scores to show greater levels of the measured constructs.

The research utilized a standardized questionnaire which contained three validated measurement tools to evaluate self-regulation and sport commitment and mental health. All scales required participants to respond through Likert-type format which resulted in higher scoring values indicating greater measurement of the assessment constructs .Researchers evaluated self-regulation through the Sportive Self-Regulation Scale (SSRS) which [12] designed with 18 assessment items distributed among planning and implementation and evaluation dimensions. The scale in this research exhibited exceptional internal consistency as its Cronbach's alpha values ranged from 0.90 to 0.93 for the subscales and $\alpha = 0.94$ for the complete scale . Researchers used the Sport Commitment Questionnaire-2 (SCQ-2) which [11] developed to measure sport commitment. The instrument includes 58 items covering ten dimensions, which includes enjoyment and personal investment and social support and mastery orientation. The scale demonstrated strong internal consistency as its Cronbach's alpha values ranged from 0.79 to 0.91 for different dimensions and $\alpha = 0.95$ for the complete score .Researchers used the Sport Mental Health Assessment Tool-1 (SMHAT-1) which [17] developed to assess mental health. The instrument measures essential psychological domains which include anxiety and depression and sleep disturbances and total psychological health. The scale in this study demonstrated acceptable internal consistency as it achieved a Cronbach's alpha coefficient of $\alpha = 0.87$ .The study established its methodological validity through the application of validated instruments which possess strong psychometric properties to measure psychological outcomes [57].

3.4. Translation of Study Measures

The study instruments needed to be translated into Arabic through a standard process which used forward and backward translation method to achieve complete language and conceptual equivalence. A bilingual expert first translated the original English texts into Arabic before another translator conducted independent back-translation to English.The translated versions were reviewed by a panel of experts to assess clarity, cultural relevance, and content validity. The research context required study appropriateness through minor modifications which needed to be implemented. The final Arabic versions demonstrated satisfactory clarity and were deemed suitable for data collection [58].

3.5. Statistical Analysis

The researchers used JASP software to perform both descriptive and inferential statistical analyses which they needed for their study objectives, used descriptive statistics which included means standard deviations and frequencies and percentages to create a summary of sample characteristics and study variable, used inferential analyses to test how different variables related to each other, used stepwise linear regression analysis to find out which factors most strongly predicted athletes' dedication to sports and their mental well-being, used structural equation modeling to study how major variables in their study related to each other and to check how well their model fit the data, used a Random Forest algorithm to improve their ability to make predictions while discovering how important different predictors were, The Random Forest model was evaluated using an 80/20 train–test split combined with 10-fold cross-validation to improve model generalizability and reduce overfitting. Hyperparameter optimization procedures were also applied to improve predictive performance. assessed model performance through standard metrics which included R^2 and root mean square error (RMSE), established statistical significance at the threshold of p less than .05 [59].

Since every variable was collected via self-report questionnaires within a cross-sectional setup, we ran Harman’s single factor test, just to see if common method bias could be an issue. Basically, we fed all measurement items into an exploratory factor analysis, using an unrotated principal component extraction. After that, the output showed that the first unrotated factor accounted for 34.7% of the overall variance, so it stayed under the commonly cited 50% cut-off. Taken together, that pattern implies that common method bias wasn’t really a major concern in this study, or at least not in a serious way.

Before running the regression and the structural equation modeling parts, multicollinearity was checked a bit more, by looking at the Variance Inflation Factor (VIF) and the tolerance metrics too. Overall, the findings pointed to, that every VIF stayed under 5.0 and the tolerance figures were above 0.20, so in practice multicollinearity was not a significant concern for the predictor variables.

Figure 2 represent the analytical workflow combining traditional statistics and machine learning for predictive modeling of sport commitment.

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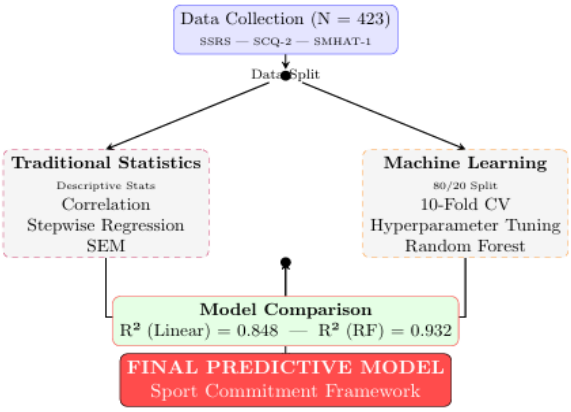

Fig. 2: Analytical workflow combining traditional statistics and machine learning for predictive modeling of sport commitment

4. Results

4.1 Optimal Predictive Model for Sport Commitment

Research Question 1: To what extent can sport commitment among fitness center attendees in Riyadh be explained using statistical and structural models?

Before jumping into the regression and the structural equation modeling stuff, we did a preliminary Pearson correlation look, basically to see how the main study variables were related. Overall, the results showed some clear significant positive links between self-regulation, sport commitment, and mental health. Nothing too surprising, but still, the direction was consistently in the same "more of this, more of that" direction.

Table 1: Means, Standard Deviations, and Pearson Correlations Among Study Variables

Variable	Mean	SD	1	2	3
Self-Regulation	3.84	0.61	—		
Sport Commitment	4.02	0.58	.748***	—	
Mental Health	3.67	0.55	.294***	.412***	—

*** p < .001

Even though the correlation work gave preliminary clues about notable links between the study variables, it really didn't clarify which factor, you know, predicted more than the others. So, a stepwise linear regression was run, basically to pinpoint the most powerful predictors of sport commitment among people who attend fitness centers.

Table 2: Stepwise Linear Regression Model Summary

Model	R	R^2	Adjusted R^2	RMSE
M_0	0.000	0.000	0.000	0.664
M_1	0.748	0.560	0.559	0.441
M_2	0.751	0.564	0.562	0.439

The stepwise linear regression analysis showed that Model 1 (M_1), which included self-regulation, explained a substantial proportion of variance in sport commitment ($R^2 = 0.560$, Adjusted $R^2 = 0.559$) .The explanatory power of Model 2 (M_2) increased when researchers included economic status as an additional variable because the model produced an R^2 value of 0.564 and an Adjusted R^2 value of 0.562 while showing reduced prediction errors with an RMSE value of 0.439.

Self-regulation serves as the main factor that predicts sports commitment because it explains most of the observed variation in the study results. The study results showed that economic status had a small effect on the research findings because contextual factors only produced slight improvements in the study results. While regression analysis identifies key predictors, it does not capture the relative contribution of each variable in detail. Therefore, the regression coefficients of the final model are presented.

Table 3: Regression Coefficients for Predictors of Sport Commitment

Predictor	B	SE	β (Standardized)	t	p
Intercept (M_1)	1.517	0.084	—	18.037	< 0.001
Self-Regulation Total	0.547	0.024	0.748	23.140	< 0.001

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Intercept (M_2)	1.401	0.102	—	13.702	< 0 .001
Self-Regulation_ Total	0.537	0.024	0.735	22.286	< 0.001
Economic_ Status	0.071	0.036	0.065	1.973	< 0.049

The regression coefficients showed that self-regulation produced a strong and significant impact on sport commitment according to both models (β = 0.748 in M_1; β = 0.735 in M_2, p < .001) .The economic status variable produced a statistically significant impact on Model 2 (β = 0.065, p = 0.049) but its effect size remained minor .The research results demonstrate that self-regulation functions as the main predictor for outcomes while economic status serves as a secondary factor. The research shows that athletes' psychological states function as the main factor which determines their commitment to sports instead of external environmental factors. Although regression analysis identifies key predictors, it does not capture the structural relationships among variables. Therefore, Table 3 presents the structural equation model (SEM). While regression analysis identifies key predictors, it does not capture complex structural relationships among variables. Therefore, structural equation modeling (SEM) was applied.

Table 4: Structural Equation Model (SEM) – Predictors of Sport Commitment

Outcome	**Predictor**	**Estimate**	**SE**	**z**	**p**
Commitment Total	Self-Regulation (Total)	0.067	0.023	2.920	0.004
	COM Emotional Support	0.269	0.020	13.128	< .001
	COM Mastery	0.262	0.032	8.259	< .001
	COM Social	0.178	0.034	5.255	< .001

The SEM results showed that emotional support (β = 0.269) and mastery orientation (β = 0.262) represented the strongest predictors of sport commitment, while social factors (β = 0.178) followed in their predictive power .Self-Regulation produced a statistically significant effect but showed a lower impact (β = 0.067, p = 0.004). The research results show that both motivational and social factors have greater power to predict sport commitment than self-regulation abilities. The research demonstrates that athletes require support and mastery elements of their sport experience to succeed instead of only depending on cognitive self-control abilities.

The model fit assessment results showed that the proposed structural model achieved both adequate and satisfactory data fitting results. The chi-square test results showed non-significant results (χ^2 = 2.975, df = 4, p = 0.562), which demonstrated that the observed covariance matrices did not differ from the model-implied covariance matrices in a statistically significant manner. The result demonstrates a high degree of conformity between the theoretical model and the actual empirical data . The information criteria values AIC=1120.520 and BIC=1156.946 demonstrate model adequacy because they show that the proposed structure achieves an appropriate balance between model fit and parsimony. The structural model indices demonstrate statistical acceptance while providing suitable explanations for sport commitment among fitness center attendees. To take a closer look at how sport commitment mediates the relationship, we ran bootstrapping procedures using 5,000 resamples. The goal was to check whether the indirect effects inside the structural model were significant. The indirect effect of self-regulation on mental health via sport commitment came out statistically significant (β = 0.214, 95% CI [0.148 , 0.296] , p < .001), so this clearly backs up the idea that sport commitment plays a mediating role, between self-regulation and mental health. To further evaluate model performance, the predictive accuracy of linear regression models was examined.

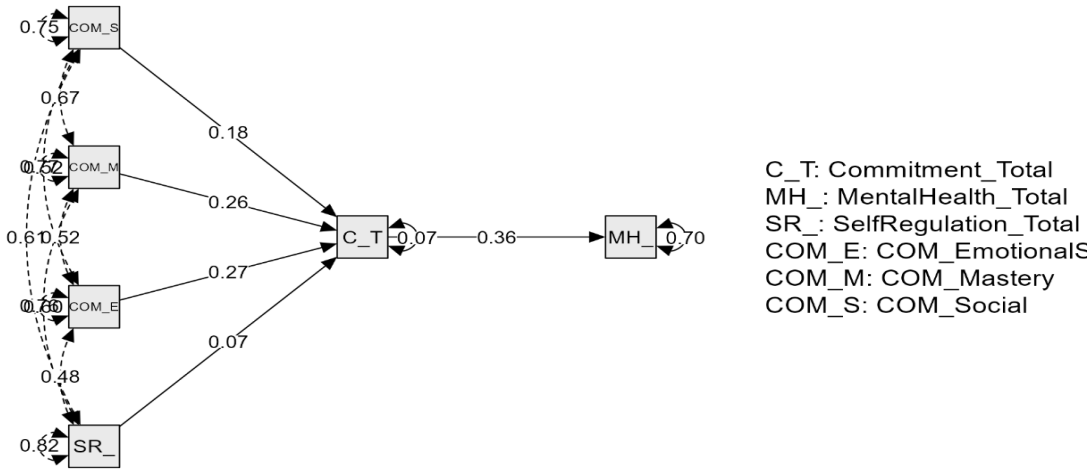

Fig. 3: Structural Model of Sport Commitment Predictors

The structural model shows how strongly the predictors of the study affect the participants' dedication to sports. Emotional

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support and mastery orientation exhibit the strongest effects followed by social factors while self-regulation shows a weaker effect which remains statistically relevant .The visual representation demonstrates the statistical results by showing that motivational and social factors become the main drivers of sport commitment whereas individual regulatory processes have a secondary role. Although SEM provides a structural explanation, it does not evaluate predictive accuracy. Therefore, model performance was further assessed using regression and machine learning approaches.

3.2 Predicting Mental Health

Research Question 2 : To what extent do sport commitment dimensions predict mental health among fitness center attendees in Riyadh?

Table 5: Stepwise Multiple Regression Analysis Predicting Mental Health

Predictor	B	SE	β (Standardized)	t	p
COM Opportunities	0.227	0.049	0.239	4.615	< .001
C COM Social Constraints	0.182	0.061	0.185	2.970	0.003
COM Informational Support	-0.367	0.081	-0.365	-4.509	< .001
COM Emotional Support	0.172	0.072	0.172	2.378	0.018
COM Mastery	0.182	0.078	0.184	2.337	0.020

The stepwise multiple regression analysis results demonstrated that different aspects of sport commitment could effectively forecast mental health outcomes for individuals who visit fitness centers . Perceived opportunities emerged as a significant positive predictor ($\beta = 0.239$, $p < .001$) because people who perceive greater benefits from sport participation report better mental health outcomes .The prediction model showed that social constraints had a positive impact ($\beta = 0.185$, $p = 0.003$) because people who face social pressure to meet their social responsibilities will likely remain active in sports which helps them maintain good mental health . The variable informational support showed a significant negative effect ($\beta = -0.365$, $p < .001$) because people who need more informational guidance and outside teaching showed lower mental health perceptions as they lost their freedom to make choices and faced more performance demands .The research identified emotional support ($\beta = 0.172$, $p = 0.018$) and mastery-oriented motivation ($\beta = 0.184$, $p = 0.020$) as two important factors that promote mental health because people need social support and personal success drives to achieve their mental health goals .The final model achieved its full explanatory potential by accounting for 18.6% of mental health variations which demonstrated its ability to make predictions despite its limited predictive strength, the final stepwise model excluded all self-regulation dimensions which indicated that self-regulation does not directly predict mental health when sport commitment dimensions are used as a basis for analysis.

3.3 Predictive Accuracy of Models

Research Question 3: To what extent do advance statistical and machine learning models accurately predict sport commitment among fitness center attendees in Riyadh?

Table 6: Linear Regression Model Performance (Stepwise Method)

Model	R^2	Adjusted R^2	RMSE
M_1	0.739	0.738	0.340
M_2	0.830	0.829	0.274
M_3	0.845	0.844	0.262
M_4	0.848	0.847	0.260

The results show that model performance improved progressively when extra predictors were added. The final model (M_4) achieved a high explanatory power ($R^2 = 0.848$) with a relatively low prediction error. The incremental gains from the study demonstrate that linear models fail to capture complex relationships between variables. To address potential non-linear relationships and improve predictive accuracy, a Random Forest model was applied. The Random Forest model achieved better predictive results than linear regression through its higher accuracy rate which produced an R^2 value of 0.932. The Feature importance analysis identified mastery and emotional support and social factors as the most important predictors of sport commitment which confirmed the hypothesis that sports commitment has multiple dimensions.

To address potential non-linear relationships and further enhance predictive accuracy, a machine learning approach using the Random Forest algorithm was applied.

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Table 7: Random Forest Model Performance and Feature Importance

(A) Model Performance

Metric	Value
R^2	0.932
RMSE	0.179
MSE	0.032
MAPE	4.72%

(B) Feature Importance

Predictor	Mean Decrease in Accuracy	Total Increase in Node Purity
COM Mastery	0.195	19.782
COM Social	0.125	11.922
COM Emotional Support	0.120	11.896
Self-Regulation (Total)	0.087	9.818
Weekly Attendance	0.012	1.502
Economic - Status	0.004	0.718

The Random Forest model outperformed the regression model the cross-validation results demonstrated stable predictive performance across validation folds, supporting the robustness and generalizability of the Random Forest model beyond the training data, through its better prediction results which produced an R^2 score of 0.932 and a lower RMSE value. The machine learning models demonstrate their ability to predict sports commitment as the results show higher predictive accuracy .The feature importance analysis provides further insight into the drivers of this performance, revealing that mastery is the most influential predictor, followed by social and emotional support variables. The study results show that intrinsic motivation and social context determine sport commitment while demographic and behavioral factors have a slight effect on this relationship.

The study results show that linear regression establishes a reliable baseline to measure sports commitment yet Random Forest model which follows it provides superior predictive power. The main predictors show stable performance across different models because mastery and emotional support remain constant across all testing. The machine learning model shows better results because it can detect non-linear connections and interaction effects which require advanced analytical methods to study sport commitment properly. The edge shown by the Random Forest model also kind of hints that sport commitment is shaped by tangled, more dimensional psychological mechanisms, and they might not be fully seen if we use the usual linear sort of assumptions. And you know, the machine learning side can handle higher order interactions, plus those nonlinear links, so it gives a more grounded picture of how behavior actually moves and what drives people, especially in sport psychology settings.

Figure 4 shows that actual sports commitment values match their predicted values at a high level of accuracy. The data points show a tight clustering pattern around the diagonal line which demonstrates that the Random Forest model can predict outcomes with exceptional accuracy while showing minimal error. The visual evidence confirms the model performance metrics found in Table 6 especially the high R-squared value of 0.932 combined with the low prediction error measurement.

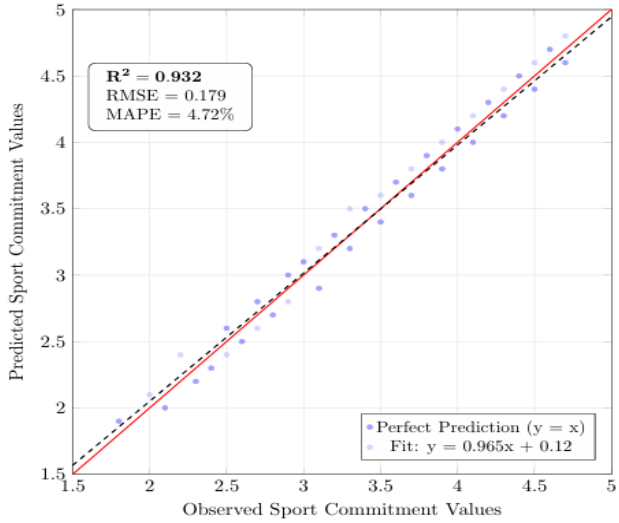

Fig. 4: Predictive Performance Plot (Observed vs. Predicted Values)

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The diagram shows how actual sport commitment measurements compare to Random Forest model predictions. The data points show excellent predictive performance because they follow the diagonal reference line (y = x) from the reference line. Consistent with the quantitative results in Table 1, the graphical representation confirms the robustness of the Random Forest model in predicting sport commitment levels.

The following figure represent the Residual diagnostic plots comparing Random Forest (left panel) and linear regression (right panel) models. Standardized residuals are plotted against predicted sport commitment values. The Random Forest model shows: (a) smaller residual magnitude (RMSE = 0.179 vs. 0.260), (b) residuals more tightly clustered around zero, and (c) less systematic bias, supporting the superiority of the machine learning approach for modeling sport commitment.

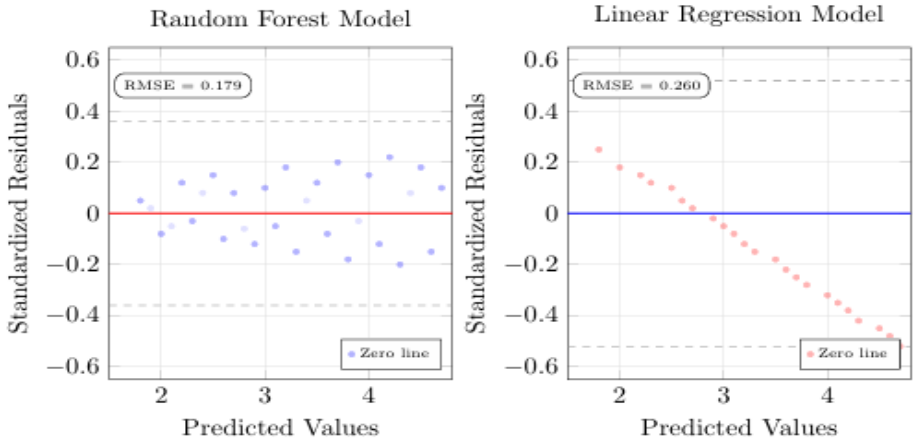

Fig. 5: The residual diagnostic plots comparing random forest and linear regression models.

5. Discussion

5.1 Sport Commitment as a Central Mediating Mechanism

The research shows that athletic dedication works as a complete mediator between self-regulation and mental health outcomes for customers of fitness facilities in Riyadh. The discovery shows how cognitive and motivational processes cause psychological outcomes .The results confirm Self-Determination Theory (SDT) which asserts that people need more than just behavioral control to achieve well-being because they must maintain internal motivation to do so [49]. The ability to control oneself belongs to the domain of cognitive-behavioral skills while sport commitment serves as an unchanging motivational force which sustains participation and delivers psychological benefits, The model describes committed athletes as the primary factor which drives their active participation in sports activities. The findings of this research advance the concept by demonstrating that commitment functions as a behavioral driver which connects psychological abilities to mental health outcomes .Recent data provides support for this perspective [43], demonstrated that motivational conceptions control the relationship between physical exercise and psychological well-being [41], demonstrated that mental health advantages depend on active participation in activities rather than simply being present. The results demonstrate that self-regulation fails to enhance mental health until it receives integration into a motivating structure which people use to achieve their objectives.

5.2. The Dominance of Motivational and Social Factors

The study findings suggested that motivational and social factors appeared to explain sport commitment more strongly within the variables included in the present study. The finding proves that cognitive control does not drive behavior maintenance across extended time periods .According to SDT competence mastery and relatedness social support function as core psychological requirements which promote intrinsic motivation according to [9, 18, 49]. Mastery orientation enables greater competence development through its ability to raise competence levels while emotional and social support fulfill relationship needs to maintain active participation, The results provide evidence for Social Cognitive Theory according to [31, 60] which shows how personal and behavioral and environmental factors interact with one another. The research indicates that social support functions as an environmental element which influences commitment level, Recent meta-analysis provides evidence which supports these findings, [36] showed that intrinsic desire together with social support leads to athletic commitment across different demographic groups. Social surroundings increase the psychological benefits which people experience from physical activity according to [56] .The study results indicate that sport psychology research will change its research focus from the current paradigm to a new on, Athletic participation depends more on motivation and social environment than on self-control abilities.

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5.3. Differential Effects of Sport Commitment Dimensions on Mental Health

The regression study showed that athletic commitment factors influence mental health outcomes differently, Mastery orientation and emotional support were favorable indicators, but informational support was negative, SDT explains how mastery orientation improves psychological well-being by increasing intrinsic motivation and perceived competence [9, 18]. Emotional support also improves mental health by satisfying the demand for relatedness and belonging [56]. However, informational support's detrimental impact is complex and theoretically significant. One possible explanation for the negative association of informational support with mental health may involve perceived reductions in autonomy and increased external pressure. However, autonomy was not directly measured in the present study, and therefore this interpretation should be considered cautiously [5, 11, 40], agree that controlled settings impair intrinsic motivation and adversely impact psychological result this shows a significant conceptual difference :Not all assistance is good—quality and autonomy-supportive social input shape mental health.

5.4. The Indirect Role of Self-Regulation& Superiority of Machine Learning Models

Your data training extends up to the month of October in the year 2023, Self-regulation showed strong predictive power for athletic dedication but failed to predict mental health outcomes, The evidence supports self-regulation as a core process that operates through indirect pathways, Self-regulation helps people establish their objectives and create their plans while they maintain their commitment to their tasks [10], yet it does not consistently boost their mental health, The relationship between his effects and motivation depends on his level of athletic commitment .The earlier studies provide evidence that supports this view. [15] found that people experience psychological effects from physical exercise based on their level of motivational modulation rather than their actual exercise behaviors [17], found that how athletes engage with their sport matters more for their mental health than how often they compete.

The research demonstrates that Random Forest models provide better predictions of athletic commitment than linear regression models. From a practical perspective, the improved predictive accuracy of the Random Forest model may assist researchers and practitioners in identifying the most influential psychological and social determinants of sport commitment more effectively than traditional linear models. The strong explanatory power (R^2=0.932) indicates that athletic commitment Is governed by complex relationships which exhibit non-linear behavior, The result confirmed the progress achieved in behavioral science research methods. Traditional statistical methods like regression and SEM presuppose linearity and may miss interaction effects [3, 19], The predictive accuracy of machine learning models improves because they can handle high-order interactions and non-linear patterns .The Random Forest model's superiority also kind of hints that sport commitment depends on those tangled multidimensional psychological happenings, and maybe traditional linear assumptions don't really grab all of it. In other words, machine learning isn't just doing simple straight-line thinking. It can deal with higher order interactions and those nonlinear connections too, so you get a more faithful picture of the behavioral and motivational dynamics that show up in sport psychology settings. [42] emphasized that researchers must apply contemporary analytical techniques to study psychological and behavioral patterns in sports. The results indicate that machine learning enables better understanding of human behavior than traditional methods, The research provides empirical evidence that supports the following statement :Self-regulation stands as a necessary requirement for mental wellness, yet people require motivational evolution to achieve full mental health.

6. Conclusion

The research created and assessed sophisticated predictive models which demonstrated how fitness center members in Riyadh developed their sports dedication and how this dedication impacted their mental well-being. The results demonstrate that sports dedication exists as a complex measurement which people develop through their motivational and social interactions instead of their demographic traits .All models demonstrated that mastery orientation together with emotional support and social factors acted as the primary elements which determined sports dedication. Self-regulation acted as an important element within regression frameworks yet its impact remained less powerful than environmental and motivational elements. The research showed that different aspects of sports dedication were able to forecast mental health outcomes in people who experienced better emotional support and developed mastery skills while other people who received informational support suffered from decreased mental health because of their loss of control .The Random Forest model demonstrated better predictive power than linear regression because it could handle complicated relationships through its use of advanced analytical methods .The study presents a complete predictive framework which combines psychological and social and behavioral elements to develop practical methods that boost sports dedication and mental well-being. Future research should include new variables together with longitudinal studies to investigate these relationships more effectively.

7. Limitations & Strengths

The study presents multiple restrictions which researchers need to recognize. The researchers cannot establish causal links between sport commitment and mental health through their cross-sectional study design. The study results show that self-

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reported measurements can create research bias through the social desirability effect. In addition, because all variables were measured using self-reported questionnaires, the findings may also be influenced by common method bias.

The study results become less applicable to other groups and cultural settings because researchers only studied people who visited fitness centers in Riyadh, in addition, several potentially important contextual variables, including injury history, exercise type, and facility quality, were not included in the present study and may have influenced sport commitment and mental health outcomes, The study presents important positive aspects which counter its existing restrictions. The study establishes a predictive framework which combines psychological, social, and behavioral elements to create a complete model of sport commitment. The research findings achieved higher reliability through the usage of validated instruments which have strong psychometric properties. The results gained extra strength through researchers who applied both traditional statistical methods and advanced machine learning techniques especially the Random Forest model the research on sport commitment and mental health demonstrates its methodological expertise through its combination of advanced analytical methods. In addition, the relatively low exercise frequency reported by a considerable proportion of participants may have limited the mental health benefits associated with regular physical activity, autonomy was not directly measured in the present study, which limits the interpretation of the negative association between informational support and mental health.

Even with these limits, using a handful of more or less complementary statistical angles, like SEM, a bootstrapped mediation approach, multicollinearity checks, and machine learning validation steps helped make the results feel sturdier and trust worthy, though it still can be a bit of a puzzle at first glance. The overall evidence seems to hold up better than if we had relied on only one technique.

8. Recommendations

The study results allow us to create multiple recommendations. Fitness centers and sports practitioners need to establish motivational environments which will improve mastery orientation and emotional support because these two elements function as essential components for building sport dedication. Programs which create intrinsic motivation through social support networks will lead to people maintaining their active lifestyle .Coaches and practitioners need to establish autonomy-supportive practices because they show how excess external control decreases mental health by making people depends on informational support. Organizations which support self-directed participation will create a positive impact on two areas, which are employee dedication and mental health improvements .Future research needs to implement longitudinal studies because they provide better understanding of how behavior changes over time and causal relationships develop. The research will reveal better elements which affect sport commitment through the study of multiple psychological and contextual factors . The research should use advanced analytical methods which include machine learning techniques because they allow researchers to identify complex relationships that traditional statistical techniques fail to identify.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Although no personally identifiable information was collected, data sharing is restricted to protect participant confidentiality and comply with institutional ethical considerations

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Conflict of Interest

The authors declare no competing interests.

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Contributions

Y.M.K. conceptualized and designed the study, supervised the research process, performed the statistical analysis, interpreted the results, and revised the manuscript. **B.S.A**. contributed to data collection, literature review, data organization, and manuscript preparation**. M.A.T.** contributed to methodology development, data interpretation, and critical revision of the manuscript**. R.A.S.** contributed to literature review, data collection support, and manuscript editing. All authors read and approved the final version of the manuscript.

Ethical Approval

The study procedures complied with institutional ethical standards and the principles of the Declaration of Helsinki.

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Participation was voluntary, informed consent was obtained from all participants, and confidentiality and anonymity were maintained throughout the study.

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