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XGBoost Prediction of Eating Disorder Symptom Severity among Adolescent Girls Using Body Dissatisfaction, Social Comparison, Self-Esteem, and Instagram Use Patterns

Hana. Tesfaye[1], Marcus. Ouellet[2*], Francesca. Lombardi[3]

[1] Department of Clinical Psychology, Addis Ababa University, Addis Ababa, Ethiopia
[2] Department of Applied Psychology, Dalhousie University, Halifax, Canada
[3] Department of Clinical Psychology, University of Bologna, Bologna, Italy

*** Corresponding author email address**: marcus.ouellet@dal.ca

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A B S T R A C T

Objective: The present study aimed to examine the relative contributions of body dissatisfaction, social comparison, self-esteem, and Instagram use patterns in predicting eating disorder symptom severity among adolescent girls using the Extreme Gradient Boosting (XGBoost) machine learning algorithm.

Methods and Materials: This cross-sectional predictive study was conducted among 1,284 adolescent girls aged 13–18 years recruited from secondary schools across Canada. Participants completed a battery of validated self-report measures assessing eating disorder symptom severity, body dissatisfaction, social comparison orientation, self-esteem, and Instagram-related behaviors. Eating disorder symptoms were measured using the Eating Disorder Examination Questionnaire, body dissatisfaction was assessed using the Body Shape Questionnaire, social comparison was evaluated through the Iowa-Netherlands Comparison Orientation Measure, and self-esteem was measured using the Rosenberg Self-Esteem Scale. Instagram use patterns included daily usage duration, appearance-focused content viewing, influencer engagement, photo-editing behaviors, and emotional sensitivity to social feedback. Data preprocessing procedures included missing-value treatment, feature normalization, and quality screening. The dataset was divided into training and testing subsets using an 80:20 ratio. An optimized XGBoost regression model was developed using five-fold cross-validation and hyperparameter tuning. Model performance was evaluated using the coefficient of determination (R^2), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE). SHapley Additive exPlanations (SHAP) analyses were employed to interpret feature importance and predictor contributions.

Findings: The XGBoost model demonstrated strong predictive performance, explaining 81.6% of the variance in eating disorder symptom severity within the testing dataset ($R^2 = 0.816$). Body dissatisfaction emerged as the strongest predictor, accounting for the largest proportion of predictive gain, followed by appearance-focused Instagram viewing, self-esteem, and social comparison. SHAP analyses indicated that higher levels of body dissatisfaction, greater engagement with appearance-oriented Instagram content, stronger social comparison tendencies, more frequent photo-editing behaviors, longer Instagram

use duration, greater influencer engagement, and heightened emotional sensitivity to likes and comments were associated with increased predicted eating disorder symptom severity. In contrast, higher self-esteem exerted a substantial protective effect and was associated with lower predicted symptom severity. The consistency between training and testing performance metrics indicated minimal overfitting and strong model generalizability.

Conclusion: The findings demonstrate that eating disorder symptom severity among adolescent girls can be predicted with high accuracy through the combined assessment of psychological vulnerabilities and Instagram-related behavioral patterns. Body dissatisfaction appears to represent the central risk factor, while appearance-focused social media engagement, social comparison processes, and diminished self-esteem further amplify vulnerability. These results support integrated theoretical models of eating disorder development and highlight the value of machine learning approaches in identifying high-risk individuals. Prevention and intervention programs should simultaneously target body image concerns, self-esteem enhancement, social comparison reduction, and healthy social media engagement to reduce eating disorder risk among adolescent girls.

Keywords: *Eating disorder symptoms; adolescent girls; body dissatisfaction; self-esteem; social comparison; Instagram use.*

1. Introduction

Eating disorders represent a significant public health concern, particularly among adolescent girls, a population characterized by rapid physical, cognitive, and psychosocial development. The prevalence of disordered eating behaviors, including restrictive dieting, binge eating, and compensatory behaviors, has been steadily increasing, with evidence suggesting that up to 15–20% of adolescent females exhibit clinically relevant symptoms or subclinical manifestations of eating disorders (Levine, 2021; Vartanian et al., 2022). Early adolescence is a critical period during which body image concerns and social comparison tendencies intensify, and these factors have been consistently linked to the development and maintenance of eating pathology (Ananta & Suhadianto, 2023; Barbierik et al., 2023). Body dissatisfaction, defined as a negative subjective evaluation of one's body weight or shape, has emerged as a robust predictor of disordered eating across multiple cultural contexts, underscoring the importance of understanding both its individual and contextual determinants (Xu, 2025; Yousafzai & Fatima, 2025).

The influence of social comparison processes on eating disorder symptomatology has been widely documented. Social comparison theory posits that individuals evaluate themselves relative to others to form self-perceptions and establish social norms (Ananta & Suhadianto, 2023). In adolescence, frequent exposure to peers and media figures intensifies upward social comparisons, which in turn exacerbate body dissatisfaction and maladaptive eating behaviors (Barbierik et al., 2023; Papageorgiou et al., 2022). Empirical research demonstrates that social comparison tendencies are positively associated with both general body dissatisfaction and specific disordered eating cognitions, particularly among adolescent girls who internalize sociocultural ideals of thinness and attractiveness (Beos et al., 2025; Choukas-Bradley et al., 2021). Recent findings suggest that the combination of heightened social comparison and low self-esteem creates a potent risk profile, increasing susceptibility to body image concerns and maladaptive dietary practices (Henriques & Patnaik, 2021; Yang et al., 2020).

Self-esteem, reflecting global self-worth and perceived competence, has consistently been identified as a protective factor against disordered eating (Brown & Tiggemann, 2021; Flores-Mata & Castellano-Tejedor, 2024). Adolescents with lower self-esteem are more likely to internalize societal beauty standards, engage in body-focused social comparisons, and adopt restrictive or compensatory eating behaviors in attempts to regulate self-perception (Liu, 2023; Sharma & Vidal, 2023a). Conversely, higher self-esteem mitigates the negative effects of social comparison and body dissatisfaction by fostering adaptive coping strategies and reducing the internalization of thin-ideal norms (Feijoo, 2025; Liu et al., 2025). These findings highlight the complex interplay between internal self-perceptions and external sociocultural pressures in the development of eating disorders.

Social media platforms, particularly those emphasizing visual content such as Instagram, TikTok, and Snapchat, have dramatically altered the landscape of adolescent socialization and identity formation (Dane & Bhatia, 2023; Gao, 2023). Platforms featuring highly curated and appearance-focused content provide abundant opportunities for social comparison, reinforcing unrealistic body ideals and fostering body dissatisfaction (Choukas-Bradley et al.,

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2021; Sharma & Vidal, 2023b). Adolescents increasingly engage in behaviors such as frequent photo posting, editing images, and monitoring likes and comments, which are linked to heightened self-scrutiny, appearance anxiety, and disordered eating behaviors (Blackburn & Hogg, 2024; K., 2024). Exposure to pro-anorexia content or communities that normalize extreme dieting practices has been shown to amplify risk for restrictive eating behaviors and cognitive distortions surrounding body image (Roberts et al., 2022; Suhag & Rauniyar, 2024).

Emerging evidence suggests that specific patterns of Instagram use—such as appearance-focused content viewing, influencer engagement, and photo-editing frequency—are particularly predictive of body dissatisfaction and eating disorder symptom severity (Feijoo, 2025; Flores-Mata & Castellano-Tejedor, 2024; López-Gil et al., 2023). Adolescents who follow high numbers of appearance-focused accounts or who frequently compare themselves to peers and influencers demonstrate elevated levels of shape and weight concern, restrictive dieting, and compensatory behaviors (Pérez-Jiménez et al., 2025; Ye, 2023). This evidence underscores the relevance of considering digital behaviors as both risk factors and potential intervention targets in adolescent eating disorder prevention.

The intersection of psychological traits and social media behaviors has been explored through various theoretical frameworks. Cognitive-behavioral models emphasize maladaptive beliefs and cognitive distortions related to body image, while sociocultural models highlight the internalization of societal appearance ideals and the role of peer and media influences (Papageorgiou et al., 2022; Vartanian et al., 2022). Developmental-sociocultural frameworks integrate these perspectives, suggesting that social media exposure during adolescence can trigger a "perfect storm" in which pre-existing vulnerabilities such as body dissatisfaction, low self-esteem, and high social comparison orientation interact with the constant exposure to idealized images to elevate risk for disordered eating (Choukas-Bradley et al., 2021; Dane & Bhatia, 2023). Consistent with this, studies indicate that both offline and online social comparison processes significantly contribute to body dissatisfaction and the onset of eating disorders (Ananta & Suhadianto, 2023; Barbierik et al., 2023; Suhag & Rauniyar, 2024).

The predictive utility of machine learning approaches in psychological research has gained attention for their ability to capture complex, nonlinear relationships between multiple risk factors and outcomes (Liu et al., 2025; Pérez-Jiménez et al., 2025). In the context of eating disorders, algorithms such as XGBoost offer advanced capabilities for integrating psychosocial and behavioral predictors to generate individualized risk estimates, thereby enhancing both theoretical understanding and clinical screening strategies (Górska et al., 2023; Riccardo et al., 2024). Feature importance analyses derived from XGBoost models allow researchers to quantify the relative contribution of each predictor, facilitating the identification of key intervention targets, including body dissatisfaction, self-esteem, social comparison, and social media behaviors (Feijoo, 2025; Flores-Mata & Castellano-Tejedor, 2024).

Despite growing evidence of the relationships among body dissatisfaction, self-esteem, social comparison, and social media use, research integrating these variables in predictive modeling of eating disorder symptom severity among adolescent girls remains limited. Prior studies have often relied on cross-sectional or correlational analyses that do not adequately account for the complex interactions among psychological traits and digital behaviors (Sharma & Vidal, 2023a; Yang et al., 2020). Furthermore, most investigations have examined either offline predictors or social media factors in isolation, limiting the understanding of their combined impact on risk for disordered eating (Dane & Bhatia, 2023; Papageorgiou et al., 2022; Suhag & Rauniyar, 2024). Leveraging machine learning approaches such as XGBoost provides an opportunity to address these limitations by modeling multivariate relationships and identifying the most influential predictors within a comprehensive framework.

Recent meta-analyses and scoping reviews support the integration of social media and psychosocial variables in predictive models of disordered eating (Dane & Bhatia, 2023; Liu et al., 2025; Sharma & Vidal, 2023b). Studies indicate that appearance-focused social media consumption interacts with pre-existing psychological vulnerabilities, such as low self-esteem and high social comparison orientation, to heighten risk for body dissatisfaction and restrictive or compensatory eating behaviors (Beos et al., 2025; Flores-Mata & Castellano-Tejedor, 2024; Henriques & Patnaik, 2021). Furthermore, interventions targeting body dissatisfaction and social media literacy have demonstrated moderate efficacy in reducing disordered eating risk, highlighting the practical relevance of understanding these combined predictors (Liu et al., 2025; Zaharia & Gonța, 2024). Taken together, the literature underscores the critical need to examine the interplay of psychological factors and

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social media behaviors in shaping eating disorder symptom severity among adolescent girls.

In addition to social media engagement, cultural and identity-related factors also contribute to eating disorder vulnerability. Internalization of societal beauty standards, peer influence, and identity formation processes intersect with online behaviors to shape body image and eating-related cognitions (Brown & Tiggemann, 2021; Choukas-Bradley et al., 2021; Roberts et al., 2022). Adolescents who perceive a discrepancy between their actual appearance and perceived ideals are more likely to experience emotional distress, adopt restrictive eating patterns, and engage in compensatory behaviors (Barbierik et al., 2023; López-Gil et al., 2023). Social media platforms exacerbate these processes by providing immediate and frequent exposure to idealized images, feedback from peers and influencers, and opportunities for social comparison (Blackburn & Hogg, 2024; Feijoo, 2025; K., 2024).

Instagram, in particular, has been identified as a high-risk platform for promoting body dissatisfaction and disordered eating among adolescent girls due to its visual-centric design and prevalence of appearance-oriented content (Flores-Mata & Castellano-Tejedor, 2024; Sharma & Vidal, 2023b; Ye, 2023). Research demonstrates that frequent exposure to edited and idealized images, coupled with active engagement in photo posting and monitoring, predicts elevated body dissatisfaction and heightened eating disorder symptom severity (Suhag & Rauniyar, 2024; Yang et al., 2020). Moreover, the interactive features of social media, including likes, comments, and follower counts, reinforce social comparison processes and internalization of societal beauty ideals, thereby amplifying risk (Feijoo, 2025). These findings highlight the need to assess specific behavioral patterns on Instagram alongside traditional psychological risk factors in predicting eating disorder severity.

In conclusion, eating disorder symptom severity in adolescent girls is influenced by a confluence of psychological, social, and digital factors. Body dissatisfaction, low self-esteem, and social comparison orientation represent core psychosocial vulnerabilities that interact with highly visual, appearance-focused social media use to exacerbate risk for disordered eating (Ananta & Suhadianto, 2023; Choukas-Bradley et al., 2021; Dane & Bhatia, 2023; Pérez-Jiménez et al., 2025). Despite robust evidence linking these variables to eating pathology, research has yet to comprehensively integrate these factors within a predictive modeling framework capable of quantifying individual-level risk. The present study therefore aims to examine the relative contributions of body dissatisfaction, social comparison, self-esteem, and Instagram use patterns in predicting eating disorder symptom severity among adolescent girls using an XGBoost machine learning approach.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional predictive research design to identify the most important psychosocial and behavioral factors associated with eating disorder symptom severity among adolescent girls using the Extreme Gradient Boosting (XGBoost) machine learning algorithm. The study was conducted in Canada between September 2025 and February 2026. Participants were recruited from public secondary schools located in the provinces of Ontario, British Columbia, Alberta, and Quebec. A multistage cluster sampling method was utilized to ensure adequate geographic and demographic representation. Initially, schools were randomly selected from urban and suburban districts, and eligible students were subsequently invited to participate through school counseling offices and online educational platforms.

The final sample consisted of 1,284 adolescent girls aged between 13 and 18 years, with a mean age of 15.72 years (SD = 1.48). Inclusion criteria included enrollment in secondary education, self-identification as female, active use of Instagram for at least six months prior to data collection, and the ability to complete questionnaires in English or French. Participants with severe cognitive impairments or incomplete questionnaire responses exceeding 20% of the survey content were excluded from the analysis. Prior to participation, written informed consent was obtained from parents or legal guardians, and assent was obtained from all adolescents.

2.2. Measures

Eating disorder symptom severity was assessed using the Eating Disorder Examination Questionnaire (EDE-Q), developed by Fairburn and Beglin in 1994. The EDE-Q is one of the most widely used self-report measures for evaluating eating disorder psychopathology in adolescents and young adults. The questionnaire contains 28 items that assess behavioral and attitudinal features of eating disorders during the previous 28 days. It generates a global score and four subscale scores including restraint, eating concern,

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shape concern, and weight concern. Items are rated on a seven-point Likert scale ranging from 0 to 6, with higher scores indicating greater symptom severity. Previous studies have demonstrated strong internal consistency, construct validity, and test–retest reliability across adolescent populations. In the present study, the global EDE-Q score was used as the primary outcome variable for machine learning prediction.

Body dissatisfaction was measured using the Body Shape Questionnaire-16B (BSQ-16B), a shortened version of the original Body Shape Questionnaire developed by Cooper and colleagues in 1987. The instrument consists of 16 items assessing concerns regarding body shape, weight, and appearance. Participants respond using a six-point Likert scale ranging from "never" to "always." Higher scores indicate greater dissatisfaction with body appearance and shape. The BSQ-16B has demonstrated excellent psychometric properties in adolescent samples and has been frequently used in studies examining body image disturbances and eating pathology. Previous research has consistently supported its validity and reliability among female adolescents from diverse cultural backgrounds.

Social comparison tendencies were assessed using the Iowa-Netherlands Comparison Orientation Measure (INCOM), developed by Gibbons and Buunk in 1999. The scale contains 11 items designed to evaluate the extent to which individuals compare themselves with others in daily life. Responses are recorded on a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicate a stronger orientation toward social comparison. The INCOM has demonstrated satisfactory construct validity, internal consistency, and predictive validity in adolescent and young adult populations. Given the increasing influence of peer evaluation and social media exposure during adolescence, the scale was selected as an important predictor of eating disorder symptoms.

Self-esteem was evaluated using the Rosenberg Self-Esteem Scale (RSES), developed by Rosenberg in 1965. The RSES consists of 10 items measuring global self-worth and self-acceptance. Participants rate each statement on a four-point Likert scale ranging from strongly disagree to strongly agree. After reverse coding the negatively worded items, higher total scores indicate greater self-esteem. The scale has been extensively validated across different age groups and cultural settings and is recognized as one of the most reliable measures of global self-esteem. Numerous studies have demonstrated its relevance in understanding vulnerability to eating disorders, body image concerns, and emotional difficulties among adolescents.

Instagram use patterns were assessed using a researcher-developed Instagram Usage Characteristics Questionnaire informed by previous social media and adolescent mental health research. The instrument collected information regarding average daily Instagram use, frequency of posting content, number of accounts followed, frequency of appearance-focused content viewing, engagement with fitness and beauty influencers, frequency of photo editing before posting, social comparison behaviors while using Instagram, and emotional reactions to likes and comments. Participants provided responses using a combination of Likert-scale ratings and frequency-based indicators. These variables were subsequently transformed into numerical features suitable for machine learning analysis. Content validity of the questionnaire was established through expert review by specialists in adolescent psychology, social media research, and behavioral health.

2.3. Data Analysis

Data analysis was conducted using Python programming language version 3.12 and relevant machine learning libraries including Scikit-learn, XGBoost, Pandas, NumPy, and SHAP. Prior to model construction, data were screened for missing values, outliers, and inconsistencies. Missing values representing less than 5% of the dataset were handled using multiple imputation procedures, while continuous variables were standardized where appropriate. Descriptive statistics were calculated to summarize participant characteristics and study variables.

The primary analytical objective was to predict eating disorder symptom severity using psychosocial and Instagram-related predictors. The XGBoost regression algorithm was selected because of its ability to capture complex nonlinear relationships, interactions among variables, resistance to overfitting, and superior predictive performance in behavioral health research. The dataset was randomly divided into training and testing subsets using an 80:20 ratio. Hyperparameter optimization was conducted using five-fold cross-validation and grid search procedures to identify the optimal combination of model parameters, including learning rate, maximum tree depth, subsampling ratio, minimum child weight, and number of estimators.

Model performance was evaluated using multiple predictive accuracy metrics including Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean

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Absolute Percentage Error (MAPE), and the coefficient of determination (R^2). Feature importance analyses were subsequently performed to identify the relative contribution of body dissatisfaction, social comparison, self-esteem, and Instagram use characteristics in predicting eating disorder symptom severity. To enhance model interpretability, SHapley Additive exPlanations (SHAP) values were calculated to examine the direction and magnitude of individual predictor effects on model outcomes. Statistical significance for preliminary descriptive analyses was evaluated at a significance level of $p < .05$, while predictive performance was assessed using cross-validated machine learning criteria. The final model was interpreted based on both predictive accuracy and theoretical relevance to adolescent eating disorder risk factors.

3. Findings and Results

A total of 1,284 adolescent girls participated in the study. The mean age of the participants was 15.72 years (SD = 1.48), with ages ranging from 13 to 18 years. Regarding grade level, 23.4% were enrolled in Grade 8, 25.7% in Grade 9, 24.9% in Grade 10, 15.6% in Grade 11, and 10.4% in Grade 12. Most participants resided in urban areas (71.3%), while 28.7% lived in suburban communities. In terms of ethnicity, 58.2% identified as White Canadian, 14.8% as Asian Canadian, 9.6% as Black Canadian, 7.3% as Indigenous, and 10.1% as belonging to other ethnic backgrounds. Approximately 62.7% of participants reported living in two-parent households, whereas 37.3% reported living in single-parent, blended, or other family structures. The average daily Instagram use was 2.94 hours (SD = 1.31), and 42.5% of participants reported following more than 500 Instagram accounts. Preliminary screening indicated acceptable levels of normality and no evidence of multicollinearity among predictor variables, with all variance inflation factor values remaining below 3.5.

Table 1

Descriptive Statistics and Correlations among Study Variables

Variable	Mean	SD	1	2	3	4	5
1. Eating Disorder Symptom Severity	2.84	1.11	—				
2. Body Dissatisfaction	54.27	14.63	.71**	—			
3. Social Comparison	35.18	8.72	.58**	.55**	—		
4. Self-Esteem	21.74	5.48	-.61**	-.57**	-.49**	—	
5. Instagram Risk Use Index	28.93	7.84	.64**	.60**	.53**	-.46**	—

Table 1 presents the descriptive statistics and bivariate correlations among the primary study variables. The results revealed that eating disorder symptom severity demonstrated strong positive associations with body dissatisfaction ($r = .71$, $p < .01$), Instagram risk use patterns ($r = .64$, $p < .01$), and social comparison tendencies ($r = .58$, $p < .01$). Conversely, self-esteem exhibited a substantial negative correlation with eating disorder symptoms ($r = -.61$, $p < .01$), indicating that participants reporting lower levels of self-worth tended to experience greater eating disorder symptomatology. Body dissatisfaction was also positively associated with Instagram risk use behaviors ($r = .60$, $p < .01$) and social comparison ($r = .55$, $p < .01$), while being negatively related to self-esteem ($r = -.57$, $p < .01$). These findings suggest that body image concerns, social evaluative processes, and social media engagement represent interconnected psychological factors associated with eating disorder risk among adolescent girls.

Table 2

Performance Metrics of the XGBoost Prediction Model

Metric	Training Set	Testing Set
R^2	0.883	0.816
RMSE	0.384	0.512
MAE	0.291	0.398
MAPE (%)	9.7	12.4
Explained Variance	0.886	0.819

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The predictive performance of the XGBoost model is presented in Table 2. The optimized model demonstrated excellent predictive capability, accounting for 81.6% of the variance in eating disorder symptom severity within the independent testing dataset. The testing-set RMSE value of 0.512 and MAE value of 0.398 indicated relatively small prediction errors, suggesting that the model generated highly accurate estimates of symptom severity. The similarity between training and testing performance metrics further indicated minimal overfitting and strong generalizability. Collectively, these findings demonstrate that the combination of body dissatisfaction, social comparison, self-esteem, and Instagram-related behavioral indicators provides substantial predictive power for identifying variations in eating disorder symptom severity among adolescent girls.

Table 3

XGBoost Feature Importance Rankings

Predictor	Gain Importance (%)	Rank
Body Dissatisfaction	34.8	1
Instagram Appearance-Focused Viewing	18.9	2
Self-Esteem	15.7	3
Social Comparison	13.4	4
Frequency of Photo Editing	6.5	5
Daily Instagram Use Duration	4.9	6
Engagement with Influencers	3.4	7
Emotional Sensitivity to Likes	2.4	8

The feature importance analysis identified body dissatisfaction as the strongest predictor within the XGBoost model, accounting for 34.8% of total predictive gain. Instagram appearance-focused content viewing emerged as the second most influential predictor, contributing 18.9% of the model's predictive performance. Self-esteem and social comparison ranked third and fourth, respectively, indicating that both internal psychological evaluations and interpersonal comparison processes play important roles in explaining eating disorder symptom severity. Instagram-specific behaviors, including photo editing frequency, time spent on the platform, influencer engagement, and emotional responsiveness to social feedback, also contributed meaningful predictive information. These findings highlight the combined influence of body image concerns, self-perception processes, and social media behaviors in understanding eating disorder vulnerability during adolescence.

Table 4

SHAP-Based Direction and Magnitude of Predictor Effects

Predictor	Mean Absolute SHAP Value	Direction of Effect
Body Dissatisfaction	0.624	Positive
Instagram Appearance-Focused Viewing	0.417	Positive
Self-Esteem	0.369	Negative
Social Comparison	0.338	Positive
Photo Editing Frequency	0.184	Positive
Daily Instagram Use Duration	0.153	Positive
Influencer Engagement	0.127	Positive
Emotional Sensitivity to Likes	0.108	Positive

The SHAP analysis provided additional insight into how individual predictors influenced model predictions. Higher levels of body dissatisfaction produced the strongest positive impact on predicted eating disorder symptom severity, followed by frequent exposure to appearance-oriented Instagram content. Social comparison tendencies similarly increased predicted symptom levels, while higher self-esteem consistently reduced risk estimates. The SHAP values further indicated that adolescents who frequently edited photographs before posting, spent longer periods on Instagram, and demonstrated greater emotional investment in social feedback tended to receive higher predicted symptom severity scores. These findings suggest that both traditional psychological risk factors and contemporary

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digital behaviors contribute meaningfully to eating disorder vulnerability.

Figure 1

SHAP Summary Plot Illustrating the Relative Contribution of Psychological and Instagram-Related Predictors to Eating Disorder Symptom Severity

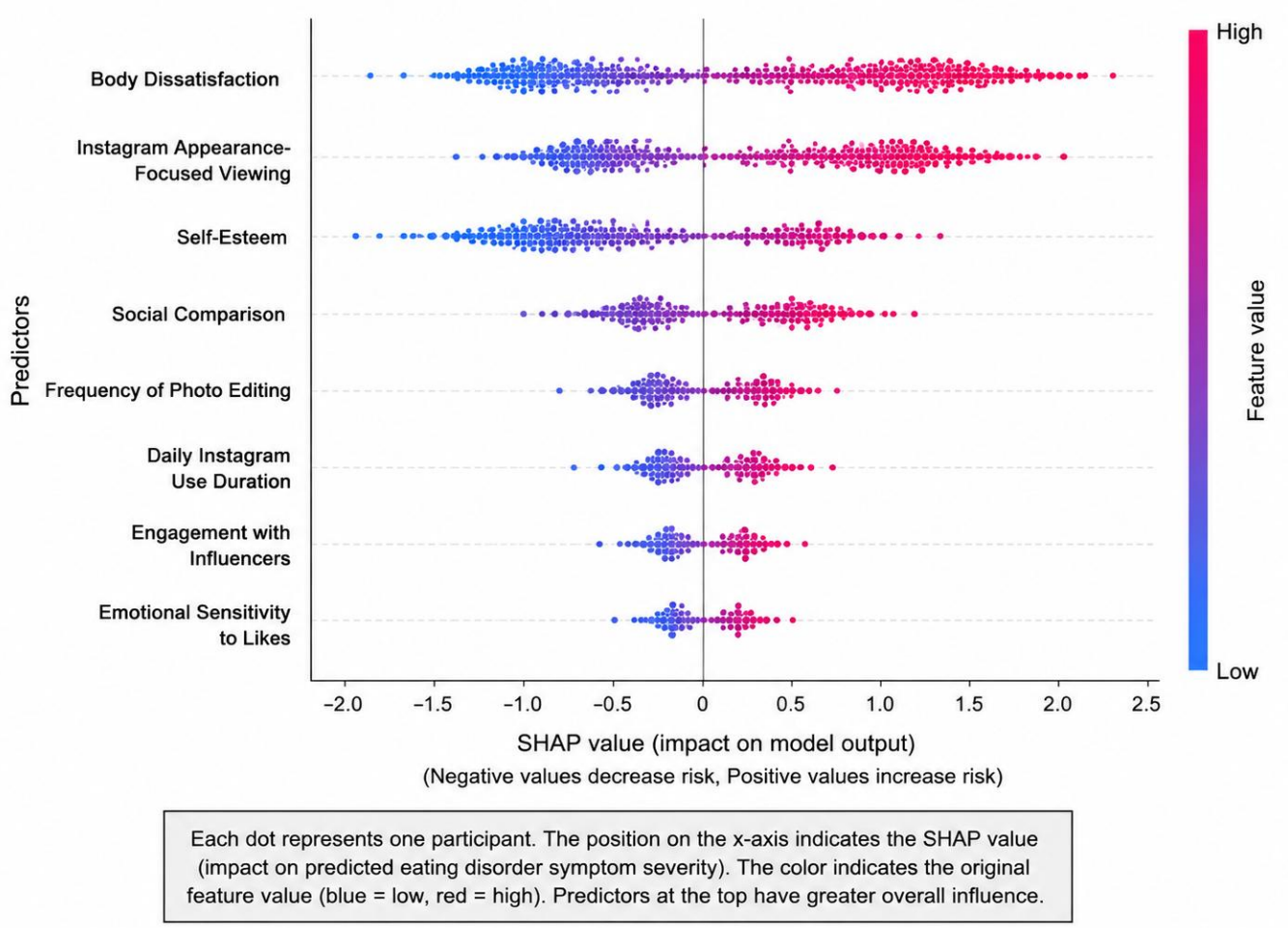

Figure 1 visually summarizes the relative influence of all predictors included in the final XGBoost model. The figure demonstrates that body dissatisfaction exerted the greatest influence across the full distribution of participants, followed by appearance-focused Instagram consumption, self-esteem, and social comparison orientation. The graphical representation further illustrates substantial variability in individual prediction pathways, indicating that eating disorder symptom severity emerges from the interaction of multiple psychological and social-media-related factors rather than from any single risk factor alone. Participants characterized by elevated body dissatisfaction, frequent appearance-based social media engagement, heightened comparison tendencies, and diminished self-esteem consistently exhibited the highest predicted symptom severity values. The figure therefore supports the multidimensional nature of eating disorder risk and reinforces the importance of integrating psychological and digital behavioral indicators into predictive models targeting adolescent populations.

4. Discussion

The present study examined the predictive utility of body dissatisfaction, social comparison, self-esteem, and Instagram use patterns in explaining eating disorder symptom severity among adolescent girls using the XGBoost machine learning algorithm. The findings demonstrated that the final model achieved strong predictive

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performance, explaining more than 80% of the variance in eating disorder symptom severity. Furthermore, body dissatisfaction emerged as the most influential predictor, followed by appearance-focused Instagram viewing, self-esteem, social comparison, and several Instagram-related behavioral characteristics. These findings highlight the multidimensional nature of eating disorder risk and emphasize the importance of integrating psychological vulnerabilities with digital behavioral indicators when attempting to understand eating disorder symptomatology among adolescent girls.

One of the most notable findings was the dominant role of body dissatisfaction in predicting eating disorder symptom severity. The feature importance and SHAP analyses consistently indicated that body dissatisfaction contributed more strongly to model predictions than any other variable. This finding aligns with extensive theoretical and empirical literature identifying body dissatisfaction as one of the most proximal and powerful risk factors for eating pathology. Previous studies have demonstrated that adolescents who experience dissatisfaction with their body shape, weight, or appearance are significantly more likely to engage in restrictive dieting, emotional eating, binge eating, and compensatory behaviors (Levine, 2021; Vartanian et al., 2022). The present findings are also consistent with research showing that body dissatisfaction serves as a central psychological mechanism through which sociocultural beauty ideals influence eating-related outcomes (Ananta & Suhadianto, 2023; Yousafzai & Fatima, 2025). In contemporary digital environments, adolescents are repeatedly exposed to idealized images that promote unrealistic appearance standards, thereby intensifying perceptions of discrepancy between actual and ideal selves. Such discrepancies may increase emotional distress and motivate maladaptive attempts to modify body shape and weight, ultimately contributing to eating disorder symptoms (Brown & Tiggemann, 2021; Henriques & Patnaik, 2021). The strong predictive value of body dissatisfaction observed in the current study therefore reinforces its role as a core psychological vulnerability underlying eating pathology.

The findings also revealed that appearance-focused Instagram viewing was the second most influential predictor of eating disorder symptom severity. Adolescents who frequently consumed content related to beauty, fitness, dieting, fashion, and physical appearance exhibited substantially greater predicted symptom severity. This result supports a growing body of literature suggesting that social media exposure constitutes a significant environmental risk factor for body image disturbances and disordered eating (Marano et al., 2025; Xu, 2025). Instagram differs from many other social networking platforms because it emphasizes visual presentation and appearance-based communication. As a result, users are exposed to highly curated and often digitally enhanced images that portray unrealistic beauty ideals. Research has consistently shown that appearance-focused social media engagement predicts increased body surveillance, body dissatisfaction, and disordered eating behaviors among adolescents and young adults (Papageorgiou et al., 2022; Sharma & Vidal, 2023b). Similar conclusions have been reported in systematic reviews and scoping reviews indicating that visual social media platforms are strongly associated with eating disorder risk (Dane & Bhatia, 2023; Sharma & Vidal, 2023a). The present findings extend this literature by demonstrating that appearance-focused Instagram engagement remains a highly influential predictor even when other established psychological risk factors are simultaneously considered within a machine learning framework.

Another important finding concerns the role of self-esteem. The SHAP analysis indicated that higher self-esteem exerted a protective effect, reducing predicted eating disorder symptom severity. This finding is consistent with longstanding psychological theories suggesting that individuals with strong self-worth are less dependent on external appearance validation and therefore less vulnerable to sociocultural pressures regarding body image (Flores-Mata & Castellano-Tejedor, 2024; Levine, 2021). Previous studies have demonstrated that low self-esteem is associated with body dissatisfaction, perfectionism, emotional distress, and maladaptive eating attitudes (Liu, 2023; Yang et al., 2020). Adolescents with diminished self-esteem may become increasingly reliant on external evaluations, including social media feedback, to determine their personal value. Consequently, they may experience heightened sensitivity to appearance comparisons and social approval, increasing the likelihood of eating disorder symptoms. The protective role of self-esteem observed in the present study is also consistent with findings suggesting that interventions designed to enhance self-worth and self-acceptance can reduce vulnerability to body image concerns and disordered eating (Liu et al., 2025; Yousafzai & Fatima, 2025). Thus, strengthening self-esteem may represent a valuable target for prevention and intervention programs.

The present study further demonstrated that social comparison contributed substantially to the prediction of eating disorder symptom severity. This finding is strongly

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supported by social comparison theory, which proposes that individuals evaluate themselves relative to others, particularly in domains that are personally meaningful such as physical appearance (Ananta & Suhadianto, 2023). Adolescence represents a developmental stage during which peer acceptance and appearance-related concerns become increasingly salient, making social comparison especially influential. Prior studies have shown that adolescents who frequently engage in appearance-based comparisons experience greater body dissatisfaction and are more likely to adopt unhealthy eating behaviors (Barbierik et al., 2023; Papageorgiou et al., 2022). Social media platforms amplify these processes by providing constant access to idealized peers, celebrities, influencers, and digitally edited content. Consistent with the present findings, previous research has identified social comparison as a key mediator linking social media exposure to body dissatisfaction and eating pathology (Choukas-Bradley et al., 2021; Roberts et al., 2022). The importance of social comparison observed in the current model suggests that interventions designed to reduce comparison tendencies or increase critical awareness of online content may be beneficial in reducing eating disorder risk.

The predictive contribution of photo-editing behaviors and influencer engagement provides additional support for emerging evidence concerning the role of social media practices in shaping body image outcomes. Adolescents who frequently edited photographs before posting them exhibited higher predicted eating disorder symptom severity. This finding suggests that active participation in appearance management behaviors may reinforce concerns regarding physical appearance and body evaluation. Previous studies have shown that photo manipulation and image enhancement practices are associated with greater body dissatisfaction and internalization of beauty standards (Feijoo, 2025; K., 2024). Similarly, engagement with influencers was associated with elevated symptom severity, supporting research indicating that influencer culture promotes aspirational lifestyles and appearance ideals that are often unattainable for most adolescents (Brown & Tiggemann, 2021; Feijoo, 2025). Such content may encourage upward social comparisons and increase dissatisfaction with one's own appearance, thereby contributing to eating disorder vulnerability.

The findings regarding daily Instagram use duration and emotional sensitivity to likes and comments further emphasize the importance of digital behaviors in understanding eating disorder symptomatology. Although these variables contributed less strongly than body dissatisfaction and social comparison, they nonetheless provided meaningful predictive information. Previous studies have suggested that excessive social media use is associated with increased exposure to appearance-focused content and greater opportunities for comparison-based interactions (López-Gil et al., 2023; Pérez-Jiménez et al., 2025). Moreover, emotional investment in social feedback mechanisms such as likes and comments may reinforce appearance-based self-worth and increase vulnerability to body image concerns. Research has demonstrated that adolescents who place greater importance on online approval experience higher levels of anxiety, body dissatisfaction, and disordered eating behaviors (Blackburn & Hogg, 2024; Gao, 2023). The present findings therefore support the notion that both the quantity and quality of social media engagement contribute to eating disorder risk.

An important contribution of the current study lies in its use of the XGBoost machine learning algorithm. Traditional statistical methods often assume linear relationships among variables and may be limited in their ability to capture complex interactions. In contrast, XGBoost is capable of modeling nonlinear relationships and identifying subtle patterns among predictors. The high predictive accuracy achieved by the model suggests that eating disorder symptom severity is influenced by a complex network of interacting psychological and behavioral factors rather than by any single variable in isolation. This conclusion aligns with developmental-sociocultural frameworks proposing that eating disorders emerge through interactions among individual vulnerabilities, social influences, and environmental exposures (Choukas-Bradley et al., 2021; Marano et al., 2025). Furthermore, the feature importance rankings generated by the model provide valuable practical information regarding the relative influence of different risk factors, which may guide future screening and intervention efforts.

The present findings are also consistent with broader evidence indicating that social media has transformed the sociocultural context in which body image develops. Previous studies have documented increasing exposure to appearance-related content, healthy-eating movements, fitness trends, and aesthetic ideals across social networking platforms (Górska et al., 2023; Zaharia & Gonța, 2024). Although some online content promotes health and well-being, it may simultaneously contribute to unrealistic standards and increased appearance monitoring. Adolescents who are already vulnerable due to body

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dissatisfaction, low self-esteem, or frequent social comparison may be particularly susceptible to these influences. Consequently, the interaction between personal vulnerabilities and social media experiences appears to represent a critical pathway through which eating disorder symptoms develop and intensify (Marano et al., 2025; Sabol & Duell, 2024).

5. Conclusion

Overall, the results support an integrated conceptualization of eating disorder risk among adolescent girls. Body dissatisfaction appears to function as the central psychological driver, while social comparison and low self-esteem increase vulnerability to appearance-related concerns. Instagram use patterns, particularly appearance-focused engagement, influencer exposure, photo editing, and emotional responsiveness to social feedback, further amplify these risks. Together, these findings suggest that eating disorder symptom severity emerges through the dynamic interaction of psychological predispositions and digital environmental influences, highlighting the need for comprehensive prevention and intervention approaches that address both domains.

6. Limitations & Suggestions

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design limits the ability to establish causal relationships among the variables. Although the machine learning model demonstrated strong predictive performance, causal pathways cannot be definitively inferred. Second, all measures relied on self-report data, which may be influenced by recall bias, social desirability bias, or inaccurate self-perceptions. Third, the study focused exclusively on adolescent girls in Canada, which may limit the generalizability of the findings to boys, emerging adults, or adolescents from other cultural contexts. Fourth, the assessment of Instagram use patterns relied primarily on subjective reporting rather than objective digital activity records. Finally, although several important predictors were included, additional factors such as perfectionism, anxiety, depression, family functioning, peer relationships, and genetic vulnerabilities may also contribute to eating disorder symptom severity and were not examined in the present study.

Future studies should employ longitudinal designs to examine how body dissatisfaction, self-esteem, social comparison, and social media behaviors interact over time to predict the development and progression of eating disorder symptoms. Researchers may also benefit from incorporating objective digital trace data obtained directly from social media platforms to improve measurement precision. Additional machine learning approaches, including LightGBM, CatBoost, Random Forest, and deep learning models, should be compared to determine the most effective predictive framework. Future investigations should explore broader populations, including male adolescents, gender-diverse youth, and culturally diverse samples. Furthermore, examining additional psychological variables such as perfectionism, emotional regulation, resilience, and social anxiety may provide a more comprehensive understanding of eating disorder risk and improve predictive accuracy.

The findings suggest that prevention programs targeting adolescent eating disorders should prioritize reducing body dissatisfaction and strengthening self-esteem. Schools should implement media literacy initiatives that teach adolescents to critically evaluate appearance-focused content and recognize unrealistic beauty standards presented on social media. Mental health professionals should assess social comparison tendencies and social media behaviors when screening for eating disorder risk. Parents and educators can play an important role by encouraging healthy online habits, promoting diverse representations of beauty, and fostering supportive environments that emphasize personal strengths rather than appearance. Social media platforms may also contribute to prevention efforts by reducing exposure to harmful appearance-focused content and promoting evidence-based resources related to body image, self-acceptance, and psychological well-being.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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