Validation of a Sports Betting Adaptation to the Problem Gambling Severity Index in Young Adults

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Abstract

Background. Sports betting is a rapidly growing addictive behavior, especially among young adults. As such, there is a need for measuring problem sports betting behaviors and consequences separately from established generalized gambling measures. The present study provides support for a sports betting adaptation of the Problem Gambling Severity Index (PGSI-SB).

Methods. We recruited a sample (N=221) of young adults aged 18-29 (M_{age}=24.4; 22% female; 13.2% Hispanic; 68.6% college degree) from 36 different US states. Eligibility criteria included ≥2 sports betting days in the past month.

Results. Confirmatory factor analyses showed support for both a single and two-factor model with subscales for problematic behavior (e.g., dependence) and negative consequences. The PGSI-SB was strongly correlated with the original PGSI in terms of scale-level and item-level correlations (i.e., convergent validity). Aim 3 established predictive validity of the single-factor PGSI-SB via significant associations with three indices of past two-week sports betting: frequency, number of bets, and total amount wagered. Predictive validity for the two-factor model was impacted by multicollinearity, given high correlation between subscales.

Conclusions. Findings establish the merits of a dedicated problem sports betting measure for young adults, which is a key step towards enhancing the quality and consistency of sports betting research.

Validation of a Problem Sports Betting Severity Index in Young Adults

Young adulthood is a developmental period associated with high-risk behavior and, in the US, young adults have the highest rates of problem gambling (Allami et al., 2021; Welte et al., 2015). These rates of problem gambling (i.e., 5.4%) are alarming given that gambling is an addictive behavior with clear links to health and well-being (Wardle et al., 2021), including substance use, suicidal ideation/attempts, and mental health disorders (Cowlishaw et al., 2014; Johnstone & Regan, 2020; Shaffer & Korn, 2002). Prevention is especially critical for young adults, who are navigating transitions to financial independence and are in a vulnerable developmental stage for onset of addiction (Sussman & Arnett, 2014).

Among major changes to the gambling landscape facilitated by novel online formats, sports betting is emerging as a central form of gambling for many, and is particularly attractive to young adults (Brevers et al., 2022). Sports betting is an umbrella term encompassing a growing variety of methods of wagering on aspects of a sporting event, either live or computer generated (e.g., e-sports), in which the outcome is at least partially determined by chance. Numerous forms of sports betting are becoming legalized in the US (Rodenberg, 2020), and sports betting prevalence is increasing rapidly. During 2021, there was an increase of 80% in prevalence of monthly sports betting (from 10% to 18% of adults 21+; Silverman, 2022). The growth has been most pronounced among young adults (Mercer, 2022); 28% of adults aged 21-34 bet on sports at least monthly, and 19% bet at least weekly (Silverman, 2022).

Although sports betting is correlated with traditional forms of gambling (Grubbs & Kraus, 2023), betting on sports may have unique risks and consequences (Grubbs & Kraus, 2022). It follows that the field would benefit from validated measures that are specific to problem sports betting symptoms to avoid confounding or generalizing symptoms related to traditional forms of gambling. Such a measure would enable researchers to identify antecedents, risks, and harms specific to sports betting, and could serve as a key outcome for assessment of sports betting prevention and intervention efforts.

Measurement of Problem Sports Betting

To date, we are unaware of any measures that assess problem sports betting, specifically; however, a numerous measures have been developed to assess problem gambling symptoms more broadly (see review Browne et al., 2021). Of the myriad measures, the Problem Gambling Severity Index (PGSI) has emerged as a 'gold-standard' for assessing problem gambling (Ferris & Wynne, 2001; Tabri & Wohl, 2023; Tseng et al., 2023). The PGSI is a 9-item instrument that comprises items pertaining to problem gambling behaviors/symptoms (i.e., dependence, tolerance) and negative consequences of gambling (Orford et al., 2010). Recently, it has been argued that the PGSI has better fit as a two-factor model than a single-factor, with problem behavior and negative consequences representing distinct subscales (Tseng et al., 2023), though others have counter-argued that a single-factor PGSI is still the most psychometrically sound approach to assessing problematic gambling (Tabri & Wohl, 2023). Nevertheless, Tabri and Wolf concede that there is conceptual value in the ability to measure problem behavior and negative consequences separately.

Given the merits of the PGSI for assessing general problem gambling, including its brevity and psychometric validity, a sound starting point for assessing problem sports betting is to adapt the PGSI items to refer specifically to sports betting behaviors. Recently, a similar adaptation to the PGSI was done in a study of Turkish sports bettors, with initial model fit indices supporting an acceptable model (Gökce Yüce et al., 2022). Despite the proven utility of the PGSI, and straightforward face validity of adapting the individual items, psychometric validation of a context-adapted measure is necessary (Ambuehl & Inauen, 2022). Scale adaptation – changing features of an existing measures, such as the situational context of the items – is common practice in behavioral sciences (Heggestad et al., 2019), but doing so can potentially undermine the scale's validity (Pillet et al., 2023). Thus, rigorous validation of adapted scales ensures credibility of the measured construct(s) and subsequent findings using the adapted scale.

Present Study

As sports betting is an increasingly prevalent addictive behavior among young adults, a dedicated scale to assess problem sports betting is warranted. In the present study, we provide validation of a sports betting adaptation to the PGSI, referred to hereafter as the PGSI-SB. Alongside revising item wording to

refer to sports betting, specifically, we aim to provide validation to the PGSI-SB assessing behaviors over the past 3-months, in contrast to the original PGSI that asks participants to reflect upon the past 12-months. The rationale for the 3-month period is both logistical and substantive. In terms of logistics, we see the value in using the PGSI-SB as both an independent and dependent variable, depending on the research question, and believe that the PGSI-SB will be a valuable outcome metric for forthcoming intervention and prevention efforts. As such, a 12-month scale has limited utility in assessing incremental improvement in problem sports betting, whereas a 3-month period will enable examination of shorter-term outcomes or multiple longitudinal follow-ups to examine potential maintenance and/or decay of effects. Related to longitudinal assessment, even outside of clinical trials, the ability to assess problem sports betting behavior in shorter intervals enables examining within-person effects (e.g., fluctuations in PGSI-SB over time). Table 1 shows a side-by-side of the original PGSI and the adapted PGSI-SB.

Given recent discourse on whether the original PGSI can be used either as a single-factor scale, or as a two-factor measure with subscales for problem gambling behaviors (e.g., dependence) and negative consequences, the present study also sought to test the various factor structures of the PGSI-SB (i.e., one- and two-factor solutions), given the practical value in measuring these related but conceptually distinguished subconstructs (Tabri & Wohl, 2023; Tseng et al., 2023). The goals of the present study were to: (1) test the factor structure of the PGSI-SB, (2) test convergent validity of the PGSI-SB through item-level and scale-level associations with the original PGSI, and (3) test predictive validity of the PGSI-SB in terms of associations with indices of sports betting behaviors (i.e., frequency, quantity, and amount wagered).

Method

Participants and Procedures

Participants were recruited and enrolled between June and November 2023 using social media advertisements. An initial brief unpaid screening survey was used to filter eligible participants that met the following criteria: (a) Live in the US, (b) be between the ages of 18-29, (c) engage in sports betting with a monetary wager at least twice in the past 30 days, (d) not presently in recovery or treatment for

gambling disorder, (e) pass two multiple-choice items that would be easily answered by sports bettors (e.g., “What is the basic definition of an ‘over’ in sports betting”), and (f) pass a spurious attention-check item to reduce the likelihood of fraudulent respondents seeking to answer questions in a way that would help them seem eligible for the study (i.e., “Have you ever been prescribed or used Pramipexole (also known as Mirapex) to help control your gambling?”). The research team contacted eligible participants by phone to verify their eligibility and introduce the study procedures, then sent a personalized and confidential link to the survey. Remuneration for the 20–30-minute survey was a $30 gift card. The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. All participants completed an informed consent form, all procedures were approved by the University of Washington Institutional Review Board (STUDY00017797, approved on 4/20/2023), and no adverse events were reported.

A total of 1,430 screening surveys were completed, of which 221 (15.5%) met all inclusion criteria and opted into the study. Participants were from 36 different states in the US. The sample had a mean age of 24.4 years, and 77.7% were male, 68.6% had attained a college degree, and 24.2% reported an annual household income above the nationwide median for young adults (i.e., $75,000). The sample was relatively diverse: 64.6% white, 16.4% Asian, 9.1% Black, and 10.0% other or multiple races; 13.2% reported being of Hispanic ethnicity.

Measures

The Problem Gambling Severity Index (original PGSI) is a 9-item measure of problematic gambling behavior (Ferris & Wynne, 2001). As recently debated (Flack et al., 2023; Tabri & Wohl, 2023; Tseng et al., 2023), this scale can be used as either a single-factor measure, or with separate subscales representing problem gambling behaviors (e.g., chasing losses, tolerance) and negative consequences (e.g., health-related problems from gambling). Scores from the 9 items are typically summed and can be used as a brief screener for problem gambling. In the present study, participants were asked to reflect on their gambling behaviors in the past 3 months (see Present Study, above, for rationale). Response options were “Never” (0), “Sometimes” (1), “Most of the time” (2), and “Almost always” (3).

The PGSI items were adapted so that items referred specifically to sports betting behaviors and negative consequences of sports betting (PGSI-SB). The exact wording of the stem and individual items is shown in Table 1. The PGSI-SB asked participants to reflect on their sports betting behaviors in the past 3 months and used the same response options as the original PGSI.

Indices of sports betting used to test predictive validity include frequency of sports bets, total number of sports bets placed, and total amount wagered – all of which refer to the past two weeks. For the frequency item (i.e., "In the past two weeks, on how many days did you make at least one sports bet?"), participants reported on a drop-down of 0 days to 14 days. The number of bets made in the past two weeks was assessed using a single item (i.e., "In the past two weeks, about how many unique sports bets did you make in total?"), with a drop-down list of responses ranging from 0 to 100+ bets. Finally, amount wagered in the past two weeks was assessed using a numerical text-entry question (i.e., "In the past two weeks, about how much money did you wager on sports bets, in total?").

Analytic Strategy

The analytic sample is slightly below the average sample size used for scale validation research (see review White, 2022), but given the brevity of the PGSI-SB (i.e., 9 items), our sample of 221 participants meets rule-of-thumb thresholds (e.g., 20 participants per item; Hair et al., 2006). In Aim 1, confirmatory factor analysis (CFA) was used to test the factor structure of the PGSI-SB. CFA models were estimated using the '*lavaan*' package (version 0.6.17; Rosseel, 2012) in R and based on recommendations by Kline (2023). Since the item response options were ordinal (four categories) and positively skewed, indicator variables were specified as ordered categorical variables. A diagonally weighted least squares estimator with robust standard errors and mean-and-variance adjusted test statistics (WLSMV) was used. Latent response variables were scaled using delta scaling, or parameterization, such that the total variance of the latent response variables was fixed to 1.0. Common factors were scaled using the reference variable method (e.g., Kline, 2023), in which one loading per factor was constrained to 1.0. Model fit was evaluated using the following robust test statistics: model chi-square test, root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean square

residual (SRMR). A chi-square difference test was used to formally compare the fit of the nested 1- and 2-factor models. Standardized factor scores estimated from the 1- and 2-factor CFA models were saved and used as predictor variables in Aims 2 and 3. Although sum scores may often be appropriate for scoring item sets designed to measure latent variables (Widaman & Revelle, 2023), some quantitative psychologists argue that sum scoring strictly constrains all items in the model to equivalent weight and instead recommend deriving scores from factor analysis (McNeish, 2022; McNeish & Wolf, 2020).

In Aim 2, the convergent validity of the PGSI-SB with the original PGSI was tested using item-level and scale-total correlations. Because items for both the PGSI-SB and the original PGSI were ordinal, polychoric correlations were used to examine item-level associations between PGSI-SB items and the corresponding items in the original PGSI (Boldero & Bell, 2012). Pearson correlations were used to examine scale-level associations between factor scores on the PGSI-SB and those on the original PGSI.

In Aim 3, generalized linear regressions were used to test the predictive validity of the PGSI-SB by estimating associations with three indices of sports betting behaviors (i.e., frequency, quantity, and amount wagered). Negative binomial regressions were used as the three sports betting outcomes were positively skewed count variables with overdispersion. All models controlled for sex, age, race, ethnicity, college degree attainment, and income. Four sets of models were estimated: (1) using PGSI-SB total scores, (2) using only the problem betting behaviors subscale, (3) using only the negative consequences subscale, and (4) using both PGSI-SB subscale scores.

Results

Descriptive Statistics

Univariate descriptive statistics for the PGSI-SB and the original PGSI are shown in Table 1, and correlations among the PGSI-SB items are shown in Table 2. Regarding the three sports betting behaviors examined in Aim 3, participants reported sports betting on an average of 6.41 days in the past two weeks (*SD*=4.18), placed an average of 19.9 sports bets in the past two weeks (*SD*=26.3, median=10), and wagered an average of $977.52 on sports betting (*SD*=$6,064.46, median=$150.00, range: $0-86,000) in

the past two weeks. Amount wagered was winsorized (i.e., top-coded) at 3 *SD* above the mean to reduce the influence of extreme outliers (Tabachnick & Fidell, 2019).

Aim 1: Confirming the PGSI-SB Factor Structure

Estimation of the one-factor CFA for the PGSI-SB converged to an admissible solution, and parameter estimates and model fit indices are presented in Tables 3 and 5, respectively. The model chi-square test was not statistically significant (χ^2_{WLSMV}=33.519, *df*=27, *p*=.180). If this test statistic equals 0, the model perfectly fits the data, and all observed variances and covariances perfectly equal their model-predicted counterparts (Kline, 2023). So, the higher the model chi-square statistic, the worse the fit of the model. Therefore, the model chi-square test being statistically non-significant suggested the one-factor model fit the data reasonably well. The RMSEA value was 0.034 [90% CI: 0.000, 0.066], which was below Hu and Bentler's (1999) fixed threshold heuristic suggesting that RMSEA < 0.06 indicates acceptable model fit. Similarly, values of the CFI (0.998) and SRMR (0.063) also indicated reasonably good model fit, as they were within the ranges (CFI ≥ 0.95 and SRMR ≤ 0.08) indicating "relatively good fit" according to Hu and Bentler's (1999) combination rule. All standardized factor loadings were greater than 0.68, indicating that the Pearson correlations between the common factor and the latent response variables for all nine items were strong. The internal consistency reliability of the common factor was ω=0.863, indicating good reliability.

Estimation of the two-factor CFA for the PGSI-SB also converged to an admissible solution, and parameter estimates and model fit indices are presented in Tables 4 and 5, respectively. The model chi-square test was not statistically significant (χ^2_{WLSMV}=30.136, *df*=26, *p*=0.262), suggesting that the two-factor model fit the data reasonably well. Other fit indices also suggested the two-factor model fit the data reasonably well, as the RMSEA value was 0.027 [90% CI: 0.000, 0.063], the CFI was 0.998, and the SRMR was 0.059. All standardized factor loadings on Factor 1 (i.e., problem betting behaviors) were greater than 0.57, indicating that the Pearson correlations between this factor and the latent response variables for all four items loading on this factor were fairly strong. Similarly, all standardized factor loadings on Factor 2 (i.e., negative consequences) were greater than 0.62, indicating that the Pearson

correlations between this factor and the latent response variables for all five items loading on this factor were fairly strong. The estimated correlation between the two factors was 0.93, suggesting the two factors were very strongly correlated. The internal consistency reliability of Factors 1 and 2 was ω=0.702 and ω=0.805, indicating acceptable and good reliability, respectively.

Aim 2: Testing Convergent Validity

Convergent validity between the PGSI-SB and the original PGSI was assessed in two ways: item-level and scale-level correlations. Item-level polychoric correlations between corresponding PGSI-SB and PGSI items are presented in Table 2. For all item pairs, $\rho \geq 0.81$ suggesting strong correlations between the original PGSI items and their counterparts adapted for sports betting. Regarding scale-level correlations, the Pearson correlation between the PGSI-SB and PGSI total scores was r=0.902, p<.001. The correlation between the PGSI-SB and original PGSI problem behavior subscales was r=0.900, p<.001, and the correlation between the PGSI-SB and original PGSI negative consequences subscales was r=0.901, p<.001. Therefore, item- and scale-level correlations between the PGSI-SB and the original PGSI were strong to very strong and provided evidence of convergent validity.

Aim 3: Testing Predictive Validity

Tests of associations between the PGSI-SB and three indices of sporting betting behaviors are presented in Table 6. In the first model set, PGSI-SB total scores were positively associated with the frequency and quantity of sports bets placed and the total amount of money wagered on sports bets in the past two weeks. For reference, on an exponential scale, each one-unit increase (i.e., 1 *SD*) on the PGSI-SB total score (i.e., standardized factor score; McNeish & Wolf, 2020) was associated with placing sports bets on 34% more days, placing 29% more total sports bets, and wagering 123% more money on sports bets, in the past two weeks. In the second and third model sets, the problem betting behaviors and negative consequences subscales were tested separately as predictors of each sports betting behavior. Both subscales were positively associated with the frequency and quantity of sports betting and the total amount of money wagered on sports bets in the past two weeks. For instance, each one-unit increase on

the problem betting behaviors subscale and the negative consequences subscale was associated with placing 27% and 26% more sports bets in the past two weeks, respectively.

In the fourth model set (Table 6), the two subscales were included in the same model as predictors of each sports betting behavior. With both subscales included, results were inconsistent and highly unstable. For instance, the negative consequences subscale was inversely/negatively associated with the total amount of money wagered on sports bets and the problem betting behaviors subscale was inversely associated with number of sports bets placed. Examining variance inflation factors (VIF) showed extreme multicollinearity between the two subscales (VIFs above 20 across models). As such, we believe these counterintuitive negative associations between PGSI-SB subscales and indices of sports betting may reflect suppression effects given the very strong correlation between the two subscales (r=0.93) and the positive association observed between these subscales and all three outcomes when subscales were included in separate models (Model Sets 3 and 4). Taken together, the positive associations between PGSI-SB scores and three indices of sports betting behavior generally provide evidence of the predictive validity of the PGSI-SB, but raises concern for multicollinearity when including both PGSI-SB subscales in the same model.

Discussion

As sports betting is a rapidly growing addictive behavior with substantial public health relevance, there is need for a validated index of problem sports betting. The present study tested the merits of an adapted version of the Problem Gambling Severity Index (PGSI), in which the stem and individual items refer specifically to sports betting behaviors and consequences, rather than those attributed to gambling more broadly.

The present study was largely informed by recent discourse on the suitability of the original PGSI as either or both a single scale and/or a two-factor scale assessing problem gambling behavior and negative consequences separately (Flack et al., 2023; Tabri & Wohl, 2023; Tseng et al., 2023). Using rigorous factor analysis approaches, we found evidence that the PGSI-SB has adequate-to-strong factor support as either a single encompassing measure, or as a two-factor measure with subscales for

problematic behavior (e.g., dependence) and negative consequences. Unlike Tseng and colleagues (2023), who argue that the two-factor model is *superior* to the one-factor model (for the original PGSI), we do not make such claims presently, as both formats may have conceptual utility, depending on the research question and intended usage. Indeed, evidence supporting the structure of both the one- and two-factor model is sufficient, and little is gained from making claims of superiority. Nevertheless, descriptive examination of model fit indices suggests that the one- and two-factor models are nearly indistinguishable, which indicates that researchers can use either format to align with the substantive focus of their design.

The second aim examined convergent validity with the original PGSI (Ferris & Wynne, 2001). One important caveat is that because the original PGSI entails one's gambling behaviors across all types of gambling, there is some inherent overlap between the PGSI and the adapted PGSI-SB for those who engage in sports betting. In terms of total scores, the original PGSI and the PGSI-SB were very highly correlated, as were the problem behavior and negative consequences subscales from the original PGSI and PGSI-SB. This indicates support for convergent validity, especially considering that the present sample was recruited/screened for sports betting behaviors. That is, a general sample of gamblers may not engage in sports betting to the same extent, and therefore the correlations between the original PGSI and the PGSI-SB would not be expected to be as high in a general sample. We also found that, at the item-by-item level, the PGSI-SB items have strong evidence for convergent validity, with all correlations $\rho>0.80$ for PSI-SB items with corresponding items from the original PGSI. Specific to this item-by-item analysis, these strong correlations highlight that responses to the PGSI-SB items are closely aligned with responses on the original PGSI.

The final aim examined predictive validity of the PGSI-SB with three key indices of sports betting behavior: frequency, quantity, and amount wagered. Although the present study was cross-sectional, PGSI-SB items referred to the past three months, whereas sports betting indices referred to the past two weeks, which provides some level of temporal precedence. As a single factor, the PGSI-SB was significantly associated with all three indices of sports betting, demonstrating predictive validity.

Similarly, when one subscale of the PGSI-SB was modeled, but not the other, results held in that that both subscales were significantly and positively associated with sports betting indices. However, when both subscales were modeled simultaneously, the estimates became inconsistent/unstable. Because the two subscales were highly correlated (r=0.93) and multicollinearity was present (as evidenced by variance inflation factor values), it is possible that complex suppression effects occurred (Cohen et al., 2003). Tseng and colleagues (2023) faced similar challenges to determining divergent validity between the two subscales in the original PGSI.

Despite strong correlations between the two PGSI-SB subscales, and evidence for multicollinearity when included in the same model, there may be substantive reasons to model the two constructs separately, at times. The problem behavior subscale entails items related to dependence that may be more closely tied to frequency of sports betting, whereas wagering greater amounts of money may be related to negative consequences but not necessarily behavioral dependence (Browne et al., 2021). Others have argued that the two subdimensions may be temporally related, whereby one develops problem betting behaviors that subsequently lead to negative consequences (Maitland & Adams, 2007); thus, longitudinal data/analyses may better clarify the predictive validity of the two separate subscales of PGSI-SB.

Implications

Taken together, we found that the PGSI-SB has strong structural support for use as either a single or two-factor subscale in young adults, with convergent validity of the PGSI-SB found in terms of strong correlations with the original PGSI. However, the predictive validity findings have implications for *how* the PGSI-SB can be used. As a study outcome, the PGSI-SB should sufficiently capture problem sports betting risks generally, or when research questions seek to examine negative consequences aside from or separately from problem sports betting behaviors like dependency. Examining the PGSI-SB or its subscales as an outcome has utility in clinical interventions, public health prevention efforts, and within etiological studies identifying antecedent risk-factors for problem sports betting behaviors. Conversely, studies utilizing the PGSI-SB as an independent variable or covariate should be able to use the single-

factor scale or either of the subscales individually, but researchers should take caution when attempting to include both the subscales simultaneously due to their high correlation and possible suppression effects that may cloud interpretation. That is, our results do not support the ability to include both problem sports betting behaviors and negative consequences as covariates in the same model. Finally, as it pertains to utilizing the PGSI-SB in forthcoming studies, we note that we scored this scale/subscales using factor score estimation, as recommended by McNeish and Wolf (2020), but sum scoring approaches may also be feasible in many cases (Widaman & Revelle, 2023).

Limitations and Future Directions

Although the present sample entailed young adults who engage in sports betting as a relevant group in which to test the merits of the PGSI-SB, findings may not provide support for this measure in older samples or samples outside of the US. Data were collected cross-sectionally, precluding strong evidence for longitudinal predictive validity or test/retest reliability. Whereas the original PGSI has established cutoff scores for the purpose of screening or categorizing individuals by levels of risk/severity, we were not able to establish such cutoffs presently, as doing so would require tests of sensitivity and specificity with a more established diagnosis, which was beyond the feasible scope of this study. Nevertheless, the same cutoffs/thresholds recommended for the original PGSI may be relevant for the PGSI-SB, though interpretations using these cutoffs should be made cautiously. As presently established, the PGSI-SB refers to the past three months, which we decided would hold the most utility for researchers examining clinical outcomes or conducting longitudinal studies. Nevertheless, sports betting behaviors may fluctuate around sports seasons; thus, researchers implementing the PGSI-SB should pay close attention to timing of assessments or establish validity of a PGSI-SB set to different time periods (e.g., past 12-months). Finally, the sample size was relative small for scale validation research (White, 2022), but nevertheless exceeded rule-of-thumb thresholds for CFA sample size requirements (Hair et al., 2006).

Conclusions

Findings show support for a sports betting adaptation of the widely used Problem Gambling Severity Index, which we refer to as the PGSI-SB. To bolster the strong face validity of the PGSI-SB, we

presently provide support in terms of (a) the factor structure both as a single and two-factor model, (b) convergent validity with the original PGSI, and (c) predictive validity in terms of associations with sports betting indices. Establishing the merits of a problem sports betting measure is a key step towards enhancing the quality of ongoing research efforts on this rapidly developing public health priority.

Data Sharing: Data are available upon request from the corresponding author.

Author Contributions: Both authors were involved in all phases of the research, including conception and design, analysis and interpretation, drafting and revising the paper, and providing final approval.

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Tables

Table 1

Descriptive Statistics for PGSI-SB Items

Item	*M*	*SD*	Median	Range
PGSI-SB Items				
Stem: *For these items, please think about just your SPORTS BETTING in the past 3 months*.				
1. When you think of your sports betting in the past 3 months, have you bet more than you could really afford to lose?	0.38	0.67	0	0-3
2. Still thinking about the past 3 months, have you needed to bet larger amounts of money when sports betting to get the same feeling of excitement?	0.69	0.78	1	0-3
3. When you bet on sports, did you bet again another day to try to win back the money you lost?	1.12	0.86	1	0-3
4. Have you borrowed money or sold anything to get money to bet on sports?	0.14	0.45	0	0-3
5. Have you felt that you might have a problem with sports betting?	0.50	0.70	0	0-3
6. Has sports betting caused you any health problems, including stress or anxiety?	0.60	0.73	0	0-3
7. Have people criticized your sports betting or told you that you had a problem, regardless of whether or not you thought it was true?	0.60	0.75	0	0-3
8. Has your sports betting caused any financial problems for you or your household?	0.17	0.45	0	0-3
9. Have you felt guilty about the way you bet on sports or what happens when you bet on sports?	0.67	0.77	1	0-3
Total Score	4.86	4.17	4	0-22
Problem Behaviors Subscale Score	2.33	2.02	2	0-10
Negative Consequences Subscale Score	2.52	2.52	2	0-13
Original PGSI Items				
Stem: *For these items, please think about all of your gambling and betting behaviors in the past 3 months*				
1. When you think of the past 3 months, have you bet more than you could really afford to lose?	0.44	0.74	0	0-3
2. Still thinking about the past 3 months, have you needed to gamble with larger amounts of money to get the same feeling of excitement?	0.68	0.77	1	0-3
3. When you gambled, did you gamble again another day to try to win back the money you lost?	1.23	0.87	1	0-3
4. Have you borrowed money or sold anything to get money to gamble?	0.16	0.49	0	0-3
5. Have you felt that you might have a problem with gambling?	0.55	0.73	0	0-3
6. Has gambling caused you any health problems, including stress or anxiety?	0.68	0.79	0	0-3
7. Have people criticized your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true?	0.59	0.77	0	0-3
8. Has your gambling caused any financial problems for you or your household?	0.23	0.54	0	0-3
9. Have you felt guilty about the way you gamble or what happens when you gamble?	0.74	0.83	1	0-3
Total Score	5.29	4.43	4	0-21
Problem Behaviors Subscale Score	2.51	2.02	2	0-10
Negative Consequences Subscale Score	2.79	2.77	2	0-12

Note. Response options: 0 = “Never”, 1 = “Sometimes”, 2 = “Most of the time”, 3 = “Almost always”.

Table 2

Polychoric Correlations between PGSI-SB Items

	1	2	3	4	5	6	7	8	9
1. When you think of your sports betting in the past 3 months, have you bet more than you could really afford to lose?	1.00								
2. Still thinking about the past 3 months, have you needed to bet larger amounts of money when sports betting to get the same feeling of excitement?	0.57	1.00							
3. When you bet on sports, did you bet again another day to try to win back the money you lost?	0.47	0.48	1.00						
4. Have you borrowed money or sold anything to get money to bet on sports?	0.59	0.68	0.41	1.00					
5. Have you felt that you might have a problem with sports betting?	0.64	0.48	0.47	0.74	1.00				
6. Has sports betting caused you any health problems, including stress or anxiety?	0.47	0.40	0.42	0.50	0.63	1.00			
7. Have people criticized your sports betting or told you that you had a problem, regardless of whether or not you thought it was true?	0.50	0.47	0.38	0.55	0.57	0.39	1.00		
8. Has your sports betting caused any financial problems for you or your household?	0.77	0.60	0.38	0.70	0.79	0.67	0.58	1.00	
9. Have you felt guilty about the way you bet on sports or what happens when you bet on sports?	0.60	0.44	0.35	0.37	0.62	0.58	0.29	0.67	1.00
Polychoric correlation between PGSI-SB item and corresponding item from the original PGSI	0.87	0.92	0.81	0.94	0.85	0.91	0.95	0.94	0.91

Note. Response options: 0 = “Never”, 1 = “Sometimes”, 2 = “Most of the time”, 3 = “Almost always”.

Table 3

Diagonally Weighted Least Squares Parameter Estimates with Robust Standard Errors for a 1-Factor Model of Sports Betting with Ordinal Indicators

	Unstandardized		Standardized	
Parameter	Estimate	*SE*	Estimate	*SE*
		Factor Loadings		
1. Bet	1.000	-	0.795	0.044
2. Tolerance	0.876	0.065	0.697	0.045
3. Chase Losses	0.708	0.074	0.563	0.052
4. Borrowed	0.997	0.083	0.793	0.047
5. Felt Problem	1.099	0.065	0.874	0.026
6. Health Problems	0.891	0.065	0.709	0.045
7. Criticized	0.778	0.075	0.619	0.056
8. Financial Problems	1.145	0.067	0.910	0.035
9. Felt Guilty	0.866	0.072	0.689	0.049
		Error Variances		
1. Bet	0.367	-	0.367	0.070
2. Tolerance	0.514	-	0.514	0.062
3. Chase Losses	0.683	-	0.683	0.059
4. Borrowed	0.371	-	0.371	0.075
5. Felt Problem	0.236	-	0.236	0.045
6. Health Problems	0.498	-	0.498	0.063
7. Criticized	0.617	-	0.617	0.069
8. Financial Problems	0.171	-	0.171	0.063
9. Felt Guilty	0.526	-	0.526	0.068
		Factor Variance		
Common Factor	0.633	0.070	1.000	-

Note. Response options: 0 = “Never”, 1 = “Sometimes”, 2 = “Most of the time”, 3 = “Almost always”.

Table 4

Diagonally Weighted Least Squares Parameter Estimates with Robust Standard Errors for a 2-Factor Model of Sports Betting with Ordinal Indicators

	Unstandardized		Standardized	
Parameter	Estimate	*SE*	Estimate	*SE*
		Factor Loadings		
Factor 1				
1. Bet	1.000	0.000	0.820	0.045
2. Tolerance	0.877	0.066	0.719	0.045
3. Chase Losses	0.706	0.073	0.579	0.055
4. Borrowed	1.005	0.085	0.824	0.053
Factor 2				
5. Felt Problem	1.000	0.000	0.882	0.026
6. Health Problems	0.811	0.054	0.716	0.045
7. Criticized	0.707	0.067	0.624	0.056
8. Financial Problems	1.049	0.048	0.925	0.035
9. Felt Guilty	0.789	0.058	0.696	0.049
		Error Variances		
1. Bet	0.328	-	0.328	0.074
2. Tolerance	0.483	-	0.483	0.065
3. Chase Losses	0.665	-	0.665	0.063
4. Borrowed	0.321	-	0.321	0.088
5. Felt Problem	0.221	-	0.221	0.046
6. Health Problems	0.487	-	0.487	0.064
7. Criticized	0.610	-	0.610	0.070
8. Financial Problems	0.144	-	0.144	0.064
9. Felt Guilty	0.516	-	0.516	0.068
		Factor Variances		
Factor 1	0.672	0.074	1.000	-
Factor 2	0.779	0.046	1.000	-
Factor Covariance	0.671	0.049	0.927	0.035

Note. Response options: 0 = “Never”, 1 = “Sometimes”, 2 = “Most of the time”, 3 = “Almost always”.

Table 5

Model Fit Indices for 1- and 2-Factor Models of Sports Betting with Ordinal Indicators

	1-Factor Model	2-Factor Model
No. of parameters	36	37
χ^2	33.519	30.136
Degrees of freedom (df)	27	26
p	0.180	0.262
CFI	0.998	0.998
RMSEA	0.034	0.027
RMSEA 90% CI	0.000, 0.066	0.000, 0.063
SRMR	0.063	0.059

Note. CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual.

Table 6. Negative binomial models testing predictive validity of the PGSI-SB through associations with sports betting indices in the past two weeks.

	Frequency: Number of days placing a sport bet in past 2 weeks		**Quantity**: Total number of sports bets placed in past 2 weeks		**Wager:** Total amount of money wagered on sports bets in past 2 weeks †	
	RR	**95% C.I.**	**RR**	**95% C.I.**	**RR**	**95% C.I.**
MODEL SET 1: With full PGSI-SB (one-factor)						
(Intercept)	4.52***	[2.04, 10.01]	5.50**	[1.37, 21.69]	36.67***	[5.09, 267.88]
PGSI-SB Score (single-factor)	1.34***	[1.18, 1.52]	1.29**	[1.05, 1.59]	2.23***	[1.71, 2.93]
Birth Sex (F=0, 1=M)	1.71***	[1.37, 2.13]	3.01***	[2.11, 4.24]	2.97***	[1.75, 4.91]
Age	0.99	[0.96, 1.03]	1.01	[0.95, 1.07]	1.06	[0.97, 1.17]
Race (White = Ref)						
Asian	0.89	[0.69, 1.14]	0.91	[0.62, 1.39]	3.18***	[1.82, 5.78]
Black	0.66*	[0.47, 0.93]	0.33***	[0.19, 0.57]	0.37**	[0.19, 0.80]
Other or Multiple Races	0.97	[0.72, 1.31]	0.92	[0.58, 1.52]	0.62	[0.33, 1.29]
Hispanic (No=0, Yes=1)	0.95	[0.74, 1.24]	0.81	[0.54, 1.24]	0.63	[0.36, 1.17]
College Degree (No=0, Yes=1)	1.26*	[1.00, 1.58]	1.48*	[1.00, 2.19]	0.99	[0.56, 1.77]
Household Income above $75k (No=0, Yes=1)	0.98	[0.80, 1.21]	1.04	[0.75, 1.46]	1.81**	[1.17, 2.9]
MODEL SET 2: With just Problem Betting Subscale (Covariates not shown)						
Problem Betting Behaviors	1.34***	[1.18, 1.52]	1.27**	[1.03, 1.57]	2.23***	[1.72, 2.92]
MODEL SET 3: With just Negative Consequences Subscale (Covariates not shown)						
Negative Consequences	1.30***	[1.16, 1.46]	1.26**	[1.05, 1.53]	2.06***	[1.61, 2.64]
MODEL SET 4: With Both PGSI-SB Subscales (Covariates not shown)						
Problem Betting Behaviors	1.28	[0.65, 2.54]	0.57	[0.18, 1.85]	2.94	[0.63, 14.06]
Negative Consequences	1.04	[0.56, 1.93]	2.09	[0.72, 6.08]	0.77	[0.19, 3.20]

Note: † In the models for amount wagered we winsorized the outcome to reduce the influence of extreme outliers greater than 3 *sd* above the mean. Sensitivity analyses show that interpretation is unchanged, but the winsorized model has increased precision and interpretability (Tabachnick & Fidell, 2019).