Evaluating the Impact of Physical and Emotional Stress on College Basketball Game Performance

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Github Link: https://github.com/anath703/UVA_BASKETBALL_STRESS

Summary

The main goal of this project was to prove our hypothesis that increased stress leads to poorer game performance in college basketball players. We first created a Structural Equation Model (SEM) using survey and tracking data to capture the relationship between three latent variables: physical readiness, emotional readiness, and game performance. The SEM confirmed our hypothesis and showed that players who were more physically and emotionally ready tended to perform better in games.

Next, we built a second SEM model with only physical and emotional readiness and extracted the predicted scores from this model. We then built a dashboard to track emotional readiness for each player over time and for the team as a whole.

Data

The data for our model come from four separate datasets; Catapult, Oura, Wellness Surveys, and Game Performance Statistics. We chose variables from each dataset that we believed had a direct affect on a player's overall physical or emotional stress. To compensate for time, we generated 5-day rolling averages of each measure. To factor for missing data, we then filled forward the 5-day average for up-to five days. Due to the wide range of possible values for different variables, we also created a scaled version of the data.

Catapult

The Catapult is a biometric wearable that the players wear during their practices and monitors all movements made by the players. The key measurement from the catapult that we were interested in was 'player load'. Player load is a one number measure that tells you how hard or how much energy a player exerted during practice. We did try including player load into our model and analysis but found that it wasn't a good measure of physical stress.

Force Plate

Force plate is an electronic platform used for assessing and analyzing movement, strength, and imbalances. The measure that we were most interested in was Countermovement Depth, which measures the "relationship between maximum power output and height of a vertical jump"

(Gajewski et al., 2018). It essentially measures how low a player dips before jumping. Our theory was that players who are under high physical stress will compensate by dipping lower. Since the measure was always negative, we calculated the absolute value to make it easier to work with and easier to interpret.

Oura

The Oura ring is a tech wearable that captures information about sleep, body temperature, heart rate variability, and provides an overall readiness score. Unfortunately, this dataset was not consistent, as many players do not wear the ring every night. We wanted to use this data to enhance information about the amount of sleep achieved by each player, but without consistency, we were unable to make full use of this dataset and ended up not including it in our final analysis.

Wellness Survey Data

The players take a wellness survey multiple times a week that collects information about amount of sleep, overall soreness, mood, and stress levels. While this data is subjective to each player, it provides an insight into how the players are feeling each week. This was our biggest input in our models when measuring physical and emotional stress.

Game Performance

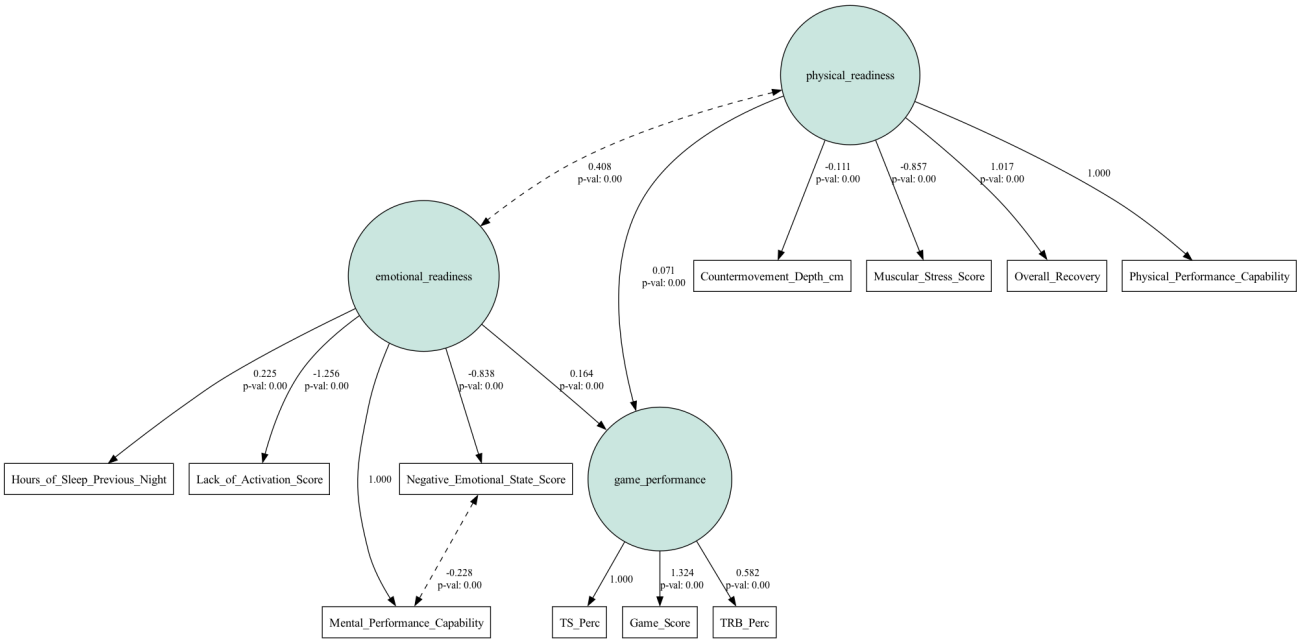
To analyze game performance, we collected game statistics from each player for each game in the season from sports-reference. The statistics we looked at specifically are true shooting percentage, total rebound percentage, turnover percentage, and game score. Game performance data was the only data that we did not calculate rolling averages or forward fill for.

Structural Equation Modeling

To evaluate game performance, we wanted to connect the measured variables from the catapult and oura rings, and the feedback from the survey questionnaires to a player's overall stress, both physical and emotional. The Structural Equation model, or SEM allows us to do that. SEMs measure and analyze the relationship between observed and latent variables. In this case, the observed data comes from the biometric feedback, survey results, and game statistics. The latent variables, which cannot be directly measured, would be the player's physical stress, emotional stress, and overall game performance.

By using an SEM model, we were able to explore this relationship, and draw connections on what causes physical and emotional stress, and how these stressors can impact game performance.

Results



The path diagram above provides a detailed and comprehensive understanding of the factors that affect game performance, revealing intriguing insights into the relationship between physical and emotional readiness and game performance. The analysis found that both physical and emotional readiness have a positive impact on game performance, with various performance indicators showing strong correlations with individual performance.

Physical readiness is an essential for an athlete's preparation and is determined by a range of factors, such as physical performance capability and overall recovery. The analysis revealed that physical readiness has a positive influence on game performance. Some aspects of physical readiness, such as muscular stress score and countermovement depth (absolute value), showed negative correlations with game performance. This aligns with our initial hypothesis that a player who is more sore and one who has to overcompensate while jumping will perform worse.

Emotional readiness also had a positive influence on game performance. The analysis showed that hours of sleep and mental performance capability have a positive impact on emotional readiness. Meanwhile, the lack of activation score and negative emotional state score had negative impacts, highlighting the importance of managing emotional well-being to optimize game performance.

Based on the fit statistics provided, the model appears to have a decent fit with the data. The Chi2 p-value of 1.000 and RMSEA of 0.000 suggests that the model's proposed relationships between variables are not significantly different from the observed data. However, the CFI value of 0.326 suggests that the model fits the data relatively poorly.

The regression equation derived from the analysis demonstrates the relationship between game performance, emotional readiness, and physical readiness. According to the equation, game performance is predicted to be influenced by both emotional readiness and physical readiness. Interestingly, the analysis revealed that emotional readiness had a more significant impact on game performance than physical readiness, with a fit statistic of 0.164 compared to 0.071 for physical readiness.

In conclusion, the path diagram analysis provided a comprehensive understanding of the factors that impact game performance, highlighting the significance of both physical and emotional readiness. The findings suggest that managing emotional well-being may be more critical than physical readiness in optimizing game performance, underscoring the importance of holistic athlete preparation that encompasses both physical and emotional well-being.

Areas of Improvement

To continue development on this model, we would recommend the following developments.

Increase compliance for consistent data

The data has many missing values due to a lack of compliance. Coaches and trainers should reiterate the importance of completing surveys and wearing tracking devices in order to increase compliance.

Lack of game performance data

One of the biggest challenges we faced in this project was how to measure the latent variable game performance. We did find several advanced player metrics that do a good job but with the season only being around 30 games, we had a small sample size of data. This was compounded by the fact that some players play very little or not at all during games. To account for this, we filtered out game performance data if a player had less than 10 minutes of playing time. Finding a way to better normalize the statistics against playing time would increase the data which we are able to evaluate the model against.

Add Data for Winning and Losing Streaks

One of the areas we wanted to explore was the effect of a winning or losing streak on the players' emotional stress. However, the season which we analyzed did not have many winning or losing streaks. The overall pattern for the season was winning and losing every other game. We believe that in a season with longer winning or losing streaks, this information may have a stronger impact on overall stress.

Opponent Strength

A factor that could influence game performance is how strong the opposing team is. Finding a way to account for opponent team strength could improve the model.

Key Takeaways

Our findings confirm our hypothesis - physical and emotional readiness improve game performance. Stress and tiredness negatively impact game performance. The key takeaways are in the underlying statistics.

One of the most important connections we discovered was the impact of sleep on emotional stress. It is important that the players get enough sleep, especially before big games, otherwise it will affect their mood, and consequently their performance.

The other interesting finding is that emotional readiness seems to impact game performance at a greater rate than physical stress. This could be for a few reasons; the players physical readiness may be more consistent or players with low physical readiness may not get as much playing time.

These insights have practical implications for coaches, trainers, and athletes themselves. Coaches and trainers can use this information to design training programs that not only focus on physical conditioning but also emphasize strategies to enhance emotional readiness. Such strategies may include developing a pre-game routine that includes mindfulness exercises or visualization techniques to promote emotional regulation, reduce stress levels and sleep hygiene education to ensure athletes are mentally prepared for optimal performance

Athletes, on the other hand, can use this knowledge to prioritize their well-being and make informed decisions about their preparation for games. They can pay attention to both their physical and emotional states, taking steps to manage stress, get adequate sleep, and engage in activities that promote mental wellness. Emphasizing the holistic approach to readiness and performance can contribute not only to on-field achievements but also to the overall well-being and resilience of athletes, enabling them to thrive both in sports and in life beyond the game.

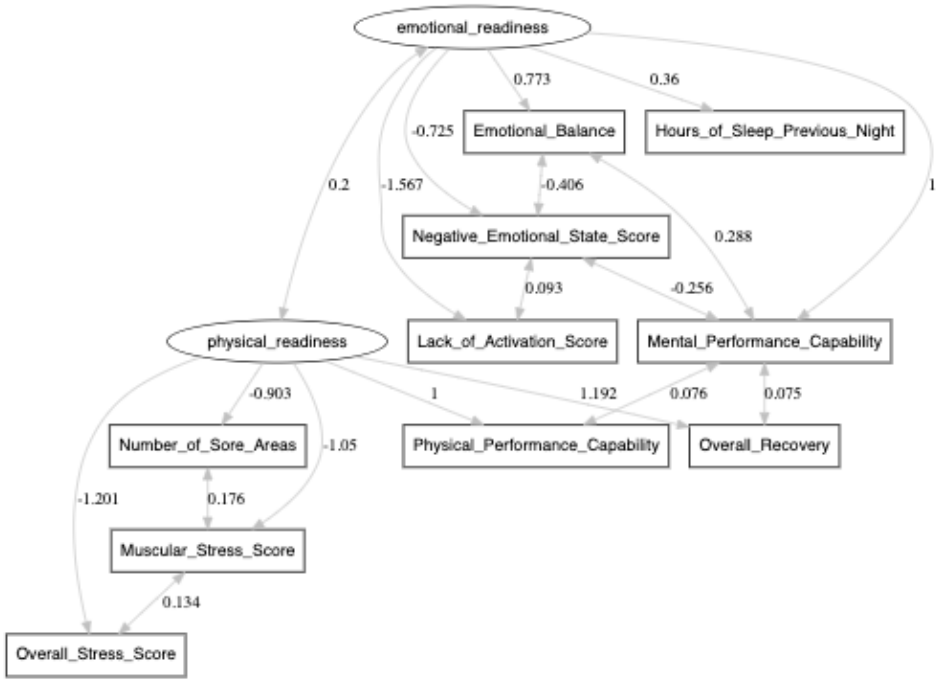
Readiness Model

After building a model to confirm the relationship between physical and emotional readiness, we next wanted to build a second model that only measured the two latent variables: physical readiness and emotional readiness. Our hypothesis was that this model would be a lot stronger since the sample size would be in the thousands instead of the hundreds due to not having to rely on sparse game performance statistics.

At this point, our experience using Semopy to build our initial SEM was frustrating. We encountered several hurdles including lack of documentation and external resources, and

missing tools. Additionally, Semopy hasn't been updated since late 2021 so it seems like the package has been abandoned by its founders. Therefore, we decided to create our next model in R using the Lavaan package. This package has been around for over a decade and the number of tools and options provided were far superior to Lavaan.

After testing various iterations, the best performing model is the one shown below. The data was unscaled in this model and used a similar 5-day forward fill and rolling average.



Though we tried various indicators such as Player Load and Countermovement Depth, our best performing SEM relied solely on responses from the wellness survey that players completed. It showed that a higher score for Emotional Balance, Hours of Sleep the Previous Night, and Mental Performance Capability increased emotional readiness. Meanwhile, increased scores for Lack of Activation and Negative Emotional State decreased emotional readiness.

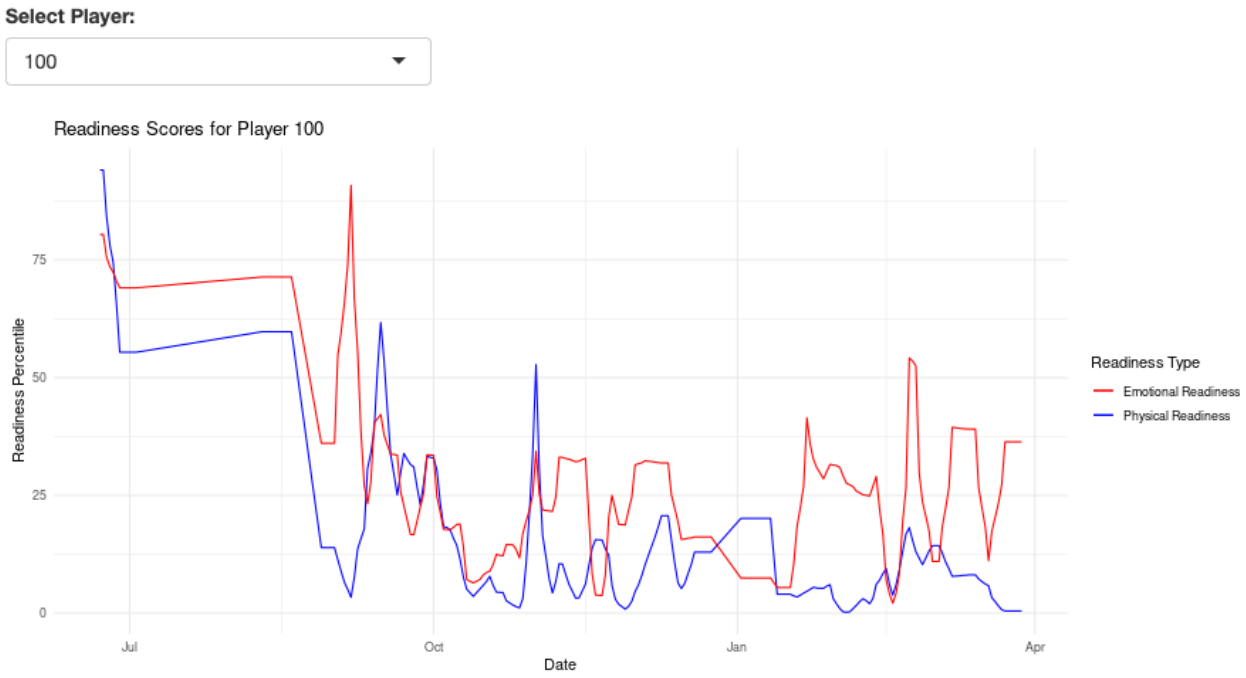
The SEM also showed that higher Physical Performance Capability and Overall Recovery scores increased physical readiness while increases in Overall Stress Score, Muscular Stress Score and Number of Sore Areas decreased physical readiness.

The fit for this model, similar to the full model, was mixed. CFI is extremely high at 0.961 well above the suggested threshold of 0.9. RMSEA is decent at 0.096 although the suggested threshold is below 0.05. The chi-squared p-value was 0.0 and below a recommended threshold

of 0.05 or higher. However, many researchers consider a null-hypothesis test for an SEM model fit “as both unrealistic and unattainable” (Peugh and Feldon, 2020).

Readiness Report

Now that we had a good model to measure physical and emotional stress, we wanted to build a practical tool that can be used by the coaching and training staff to monitor stress level for all players. Using the stress only SEM, we were able to calculate the SEM predicted physical and emotional readiness for each data point. We then converted these scores to percentiles so that they would be more intuitive and easier to interpret. Finally, we created a R Shiny dashboard to graphically display the data on a player or team level. The top section of the report shows the physical and emotional readiness percentiles of the player chosen in the drop-down menu.



The bottom section of the report shows physical and emotional readiness percentiles for all players on a chosen date.

Select Date:

2021-10-20

Show 25 entries Search:

Player_ID	Date	physical_readiness_percentile	emotional_readiness_percentile
100	10/20/2021	4.5	12.5
101	10/20/2021	82.6	64
102	10/20/2021	70.7	52.1
103	10/20/2021	47.8	73.4
104	10/20/2021	33.6	63.1
105	10/20/2021	95.7	68.1
106	10/20/2021	49.3	24.7
107	10/20/2021	73.2	73.2
108	10/20/2021	79.6	50
109	10/20/2021	34.8	11.1
110	10/20/2021	4.9	18.9
111	10/20/2021	71.4	64.8
112	10/20/2021	0.6	0.5

The coaching and training staff could use this tool to easily monitor physical and emotional readiness for their players. The report can also be modified to have additional tools and to show even more information.

Sources

- Lopes Dos Santos, Marcel, Melissa Uftring, Cody A. Stahl, Robert G. Lockie, Brent Alvar, J. Bryan Mann, and J. Jay Dawes. “Stress in Academic and Athletic Performance in Collegiate Athletes: A Narrative Review of Sources and Monitoring Strategies.” *Frontiers in Sports and Active Living* 2 (2020). https://www.frontiersin.org/articles/10.3389/fspor.2020.00042.
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