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Reference Points, Risk-Taking Behavior, and Competitive Outcomes in Sequential Settings

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Abstract

Understanding how competitive pressure affects risk-taking is crucial in sequential decision-making under uncertainty. This study examines these effects using bench press competition data, where individuals make risk-based choices under pressure. We estimate the impact of pressure on weight selection and success probability. Pressure from rivals increases attempted weights on average, but responses vary by gender, experience, and rivalry history. Counterfactual simulations show that removing pressure leads many lifters to select lower weights and achieve lower success rates, though some benefit. The results reveal substantial heterogeneity in how competition shapes both risk-taking and performance.

Keywords: Reference Point, Pressure, Risk, Sports Competition
JEL code: D90, L83, Z22, L23

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1 Introduction

Understanding the behavioral effects of reference points, particularly in the context of pressure and risk-taking, is a critical area of research. The core concept is that an individual's assessment of an outcome is influenced not only by the outcome itself but also by how it compares to a reference point (Tversky and Kahneman 1992). A significant challenge in this field is disentangling the effects of pressure from a reference point on risk-taking behavior and outcomes. Unlike controlled experimental settings as in Schwerter (2024), where risk-taking can be modeled as a binary lottery, field data presents complexities that make such decompositions difficult. In this paper, we utilize a sequential competition setting and panel dataset from official bench press competitions, offering an opportunity to explore the interplay between pressure and risk-taking behavior. This dataset enables us to observe weight attempts, outcomes, rankings, and the exogenous pressure exerted by rivals over time. By examining how pressure influences subsequent risk-taking decisions, we aim to enhance the understanding of behavior under uncertainty and contribute to discussions on optimizing competition design to maximize performance.

The primary contribution of this study is the decomposition of the effects of pressure arising from reference points into distinct elements: the choice of weight attempt (analogous to a lottery choice) and the probability of success (analogous to a lottery gain). We also explore alternative competition designs that manipulate the availability of pressure-related information. The structure of official bench press competitions provides an ideal context to study the relationship between reference points and risk-taking within the sequential game setting of weight attempts and weight lifting stages, where exogenous pressure is present. Specifically, a weight attempt under pressure from rivals can be seen as a risk-taking behavior similar to making a lottery choice. Whether the lift is successful depends on the pressure conditional on the weight attempt and the rivals' outcomes. Through this investigation, we seek to answer an analogous question in real-world competitive settings: What would be the impact on risk-taking behavior and expected outcomes if the pressure exerted by rivals were removed?

Our results demonstrate the role of pressure in shaping lifters' behavior during competition. Pressure from both lower and higher-ranked rivals leads to increased attempt weights across both the second and third attempts, reflecting lifters' tendency to challenge themselves under competition.

Regarding success probability, lifters under pressure from below show a slightly higher likelihood of success, possibly due to the motivation to defend their rank. However, when attempting to surpass higher-ranked rivals, success rates consistently decline, highlighting the difficulty of overtaking stronger competitors under pressure. This pattern is most pronounced in the third attempt, where fatigue and psychological strain may amplify the challenge. These results suggest that while competitive pressure can encourage bold strategies, it also introduces constraints that limit execution success in decisive moments.

Heterogeneity analyses further reveal that responses to pressure vary by gender, experience, and rivalry history. Male lifters exhibit stronger responses to both lower and higher rival pressure in attempt selection, whereas female lifters show a more muted response, especially under upward pressure. Female lifters experience a sharper decline in success probability when attempting to turn around a higher-ranked rival, suggesting a heightened sensitivity to stress. More experienced lifters are more sensitive to higher-ranked competitors, reinforcing the idea that competitive awareness strengthens with experience. Additionally, lifters with a history of repeated rivalry encounters show heightened sensitivity to pressure, suggesting that familiarity enhances their ability to navigate competition. For success probabilities, while pressure from lower-ranked rivals can improve outcomes, particularly among experienced lifters, upward pressure generally reduces them, with stronger effects among female competitors. Lifters with strong rivalry history show a small negative impact from upward pressure but a large positive impact from lower pressure. These confirm substantial heterogeneity.

To examine how pressure shapes the balance between ambition and feasibility in decision-making, we simulate counterfactual competition designs in which such pressure is removed. The results reveal consistent directional patterns—more conservative attempts—but also considerable heterogeneity in expected outcomes. While a subset of lifters benefit from the absence of pressure, some lifters experience lower success rates and reduced expected outcomes. These differences reflect the uneven role of external pressure: for some, it enables focus and composure; for others, it disrupts execution or leads to overly cautious choices.

More broadly, in decision-making contexts involving sequential risky choices, individuals may experience diverging outcomes depending on how they respond to the presence or absence of external competition. Particularly in the later stages of competition, ignoring external pressure and focusing on personal strategy may enhance outcomes for some, while others rely on competitive cues to sustain performance. These findings reinforce the idea that responses to pressure are highly individual, suggesting that the effectiveness of competition design depends on how one reacts to competition.

1.1 Related literature

This paper contributes to three strands of the literature: pressure from reference points, risk behavior under pressure, and competition design.

First, our paper contributes to the growing body of literature on reference points in sports competition. We follow the framework of O'Donoghue and Sprenger (2018), who suggest a variety of reference points, including the status quo (e.g., prior wealth), past experience, focal outcomes, aspirations, expectations, and other possibilities such as norms and social comparisons. However, the determination of reference points is often arbitrary and context-dependent (DellaVigna 2018), with these effects being composited and mixed in actual sports settings.[1] Table 1 summarizes the data, reference points, classifications, and the loss-gain domain of the utility function in related studies, although the classification is not perfect.

Salient numbers, such as round finish times in marathons (Allen *et al.* 2017, Soetevent 2022) and predetermined par scores in golf (Pope and Schweitzer 2011), are well-known as focal reference points. Runners adjust their effort levels to meet target times, and golf players are significantly less accurate when attempting shots ahead of a predetermined reference point, labeled as "par." [2] Goals set by athletes based on past or current performances are treated as reference points in the form of status quo, past experience, and expectations. For example, self-reported target times in marathons (Markle *et al.* 2018) and personal bests in chess (Anderson and Green 2018, González-Díaz *et al.* 2024) serve as natural reference points, whether or not they function explicitly as goals. Theoretically, Heath *et al.* (1999) and Koch and Nafziger (2016) discuss the concept of goals as reference points. In our data on bench press competition, we do not observe prevalent bunching around round weights, likely because the categories in which players participate are conditional on characteristics such as age, body weight, and gender. Additionally, unlike professional sports that provide substantial rewards, bench press competitions are amateur events with no direct monetary incentives. This setting highlights lifters' self-motivation to surpass personal bests and rank updates based on recent outcomes, independent of financial incentives. The current rank is the reference point and each lifter has more incentive to avoid a large loss from decreasing his ranking rather than to get a relatively small gain from increasing his ranking.

In terms of pressure from rivals' outcomes, the phenomenon of "choking under pressure"—where performance declines under stress—has been extensively studied. For instance, large-sample studies reject the hypothesis that first-mover advantage in soccer or being slightly behind increases the likelihood of winning in basketball, football, or rugby (Kocher *et al.* 2012, Teeselink *et al.* 2023).[3] While some papers implicitly link the cause of pressure to reference points, we do not explicitly

[1] Baillon *et al.* (2020) use Bayesian hierarchical modeling to estimate the marginal posterior distributions of six reference point rules. They found that subjects most frequently used the status quo and MaxMin as reference points.

[2] Beyond sports competition, Rees-Jones (2018) provides evidence implying that individuals have reference-dependent preferences, with zero tax due serving as the reference point. As experimental evidence, Abeler *et al.* (2011) conducted an experiment manipulating the fixed pay amount as a reference point in a real-effort task. In this experiment, either fixed pay or piecework pay for a correct answer was randomly determined after task completion. They found that subjects were more likely to stop when the expected piecework pay equaled the fixed pay, exerting more effort when the fixed pay was high. Corgnet *et al.* (2015) also show that goal setting by managers is most effective for team workers when monetary incentives are strong.

[3] Similar studies include the effects of spectators on penalty shootouts in soccer (Dohmen 2008), free throws and playoff performance in basketball (Hickman and Metz 2015, Böheim *et al.* 2019, Cao *et al.* 2011, Toma 2017, Morgulev and Galily 2018), the impact of bookmakers' odds on soccer play (Bartling *et al.* 2015), putting performance in golf (Hickman and Metz 2015), the influence of decisive moments on dart throws (Teeselink *et al.* 2020), and biathlon performance (Harb-Wu and Krumer 2019, Lindner 2017), the effect of previous game outcomes on current outcomes in hockey (Kniffin and Mihalek 2014), and gender differences in pressure in tennis (Cohen-Zada *et al.* 2017, Paserman 2023).

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classify pressure under the loss-gain utility framework, as the specific cases do not fit neatly within that domain. Our study also relates to peer effects in terms of externalities from rivals' abilities and performance. Guryan *et al.* (2009), using random assignment in high-stakes golf tournaments, find no evidence of peer effects on average. In contrast, Yamane and Hayashi (2015) observe positive peer effects in swimming competitions, particularly suggesting that being chased by peers with lower personal bests enhances performance. These mixed results indicate that peer effects vary across different contexts, with Nishihata (2022) showing that peer effects among speed skaters depend on race distance and prize money. In our study, we leverage the sequential timing of observing rivals' outcomes, applying the attempt weight, and executing the lift to decompose the effects of rivals' outcomes on both the weight selection and the success probability of the lift.

Second, this paper contributes to the literature on the effect of reference points on risk-taking actions. The most closely related studies are Puente-Moncayo (2019) and Genakos and Pagliero (2012). Puente-Moncayo (2019) examines the effect of current scores on the tendency to take high-risk shots in tennis. The author follows Ely *et al.* (2017), using the approach developed by Klaassen and Magnus (2009) (a structural model) to show that first serves should be riskier than second serves, and using two first serves (or two second serves) is suboptimal. Genakos and Pagliero (2012) study the effects of interim ranking in itself on weight application and success probability using the data of the powerlifting competition in the Olympic Games and World and European Championships between 1990 and 2006. In the experimental economics literature, Schwerter (2024) conducted experiments on risk-taking behavior when subjects were exposed to exogenously predetermined peer earnings. The author found that subjects exposed to higher peer earnings increased their risk-taking behavior. Similarly, Post *et al.* (2008) highlight the relevance of risk-taking behavior in path-dependent contexts, using data from the TV show "Deal or No Deal" and a replicated experiment where subjects choose to either "deal" for a sure prize or "no deal" to continue for an uncertain prize. Our paper is more ideal than these examples for several reasons. First, the weight selection conditional on personal bests and rivals' outcomes is analogous to choosing a lottery, where the probability of successfully lifting the weight can be inferred from data by both lifters and econometricians. Second, lifting weights involves a simple, monoarticular action, which leads to relatively fewer external factors influencing the outcomes, compared to other sports including powerlifting (Genakos and Pagliero 2012). Third, unlike Genakos and Pagliero (2012), we exploit the sequential competition design which explicitly defines revealed information to each player. Fourth, we use a universe of official bench press competitions with a richer sample size and set of variables, which have been known recently as the most important factors to detect behavioral effects in the sports data (Teeselink *et al.* 2023).

Third, our paper contributes to the literature on competition design aimed at maximizing each player's score within a group. This contribution parallels general frameworks in competition design within organizations and is related to contest theory, although sabotage and uncooperative behavior, which can occur in real-world workplace competition, are less likely in sports competition.[4] As outlined by Lazear and Oyer (2013), relative performance evaluation (RPE) exists in two forms. The first allows firms to filter out common shocks by comparing an individual's performance to that of a peer group. Gibbons and Murphy (1990) provide empirical evidence suggesting that RPE was used in the compensation contracts of U.S. CEOs from 1974 to 1986. The second form of RPE involves fixed rewards based on the performance rankings of participants, commonly referred to as a rank-order tournament. In tournament theory, as modeled by Lazear and Rosen (1981), large differences in payoffs across ranks motivate those at lower levels to exert more effort, while some risk-averse agents may exert less effort when the importance of winning is diminished. Rank-order tournaments have a wide range of applications, including sports competitions. For example, consistent with tournament theory, Brown (2011) shows that the presence of a superstar highly likely to win reduces the performance of other players. In our context, the unique structure of official bench press competitions allows us to compare alternative competition settings to the current format through simulations based on our estimates.

Following the seminal model by Lazear and Rosen (1981), tournament theory has been extended in various directions to better reflect behavioral patterns and decision-making processes observed in real-world settings. Two particularly relevant strands of this literature focus on incorporating risk-taking decisions instead of traditional effort choices and integrating reference-dependent preferences into contest frameworks. Hvide (2002), Hvide and Kristiansen (2003), and Taylor (2003) incorporate risk-taking behavior into tournament models, analyzing how participants' strategic risk choices can be influenced by their relative positions and incentives within the tournament structure. Nieken and Sliwka (2010) show that the correlation of risk outcomes affects how both leading and trailing participants adjust their risk strategies. Gill and Stone (2010) and Dato *et al.* (2018) extend tournament models by incorporating reference-dependent preferences, highlighting how loss aversion and outcome expectations can shape competitive behavior and effort provision. These extensions are closely related to our study, as they emphasize the importance of risk-taking behavior and reference-dependent preferences in tournament settings.

[4] Drago and Garvey (1998) find that strong promotion incentives reduce helping behavior, even though individual effort increases. Bandiera *et al.* (2005) show that fruit pickers reduce their effort under relative incentives when their peers are friends, due to the negative externality of individual effort on others' payoffs.

Table 1: Empirical Sports and Experimental Papers Studying Reference Points

Paper	Data	Reference Point	Classification	Loss-Gain Domain
Pope and Schweitzer (2011)	Golf	Par For Each Hole	Focal Outcomes	Score For Each Hole
Pope and Simonsohn (2011)	Basketball	Round Numbers In Performance	Focal Outcomes	Current Outcome
Allen *et al.* (2017)	Marathon	Round Finish Time	Focal Outcomes	Finish Time
Essl and Jaussi (2017)	Lab Experiment	Points (ECU) When $<, >$ 10sec	Focal Outcomes	Points From Real-Effort Task
Soetevent (2022)	Running Event	Round Finishing Time	Focal Outcomes	Finishing Time
Schwerter (2024)	Lab Experiment	Peer Earnings	Focal Outcomes	Earnings From Binary Lotteries
Post *et al.* (2008)	TV Shows	Earlier Expectations	Expectations	Bank Offer
Abeler *et al.* (2011)	Lab Experiment	Amount Of Fixed Pay	Expectations	Piece Rate For Correct Answers
Bartling *et al.* (2015)	Soccer	Expected Outcome By Odds	Expectations	Current Outcome
Markle *et al.* (2018)	Marathon	Self-Reported Target Time	Status Quo	Finish Time
Kniffin and Mihalek (2014)	Hockey	The Outcomes For Game 1	Past Experience	Score In Game 2
Anderson and Green (2018)	Chess Online	Personal Best Rating	Past Experience	Rating
González-Díaz *et al.* (2024)	Chess In-Person	Personal Best Rating	Past Experience	Rating
Berger and Pope (2011)	Basketball	Performance Of The Opponent	Social Comparison	Current Outcome
Puente-Moncayo (2019)	Tennis	Rival's Score	Social Comparison	Score
Teeselink *et al.* (2023)	Four Sports	Performance Of The Opponent	Social Comparison	Current Outcome
This Paper	Bench Press	Current Own Ranking	Social Comparison	Ranking
Baillon *et al.* (2020)	Lab Experiment	6 Rules	Mixed	Lottery Options

Notes: We follow the referent list of O'Donoghue and Sprenger (2018) which suggest a number of possibilities: the status quo (e.g., prior wealth), past experience, focal outcomes, aspirations, expectations, and other candidates including norms and social comparisons, although the reference point determination is, in ways, arbitrary and context-dependent (DellaVigna 2018) and these effects are composited and mixed in the actual sports.
6 rules (Status Quo, MaxMin, MinMax, X at Max P, Expected Value, Prospect Itself), ECU=Experimental Currency Unit.

2 Data

2.1 Data source

We use the data from OpenPowerlifting which is a community service project to create a permanent and open archive of the world's powerlifting data.[5] The OpenPowerlifting database includes a wide range of data fields of official powerlifting competition. It includes competition details such as federation name, date and location, level (local, national, international), athlete information such as name, age, weight class, gender, lift results of squat, bench press, and deadlift (with attempted weights and success/failure status), Wilks score and other relative strength metrics, and rankings of placement within the competition historical rankings and records.

In this paper, we focus on the bench press competition which is the most popular division and less complex than Squat-Bench-Deadlift (SBD) composite competition. We use all official attempts data of 15-69 aged lifters at competition categories based on age-class, weight-class, and gender, in which the number of participant lifters is at least two to capture competition pressure.

Table 2 presents summary statistics across three types of powerlifting equipment: raw, single-ply, and multi-ply. Each category includes attributes such as personal best, first, second, and third attempt weights, successful attempts, best attempt, age, and body weight. The raw category has the largest number of participants, with 175,983 individuals, an average personal best of 124.39 kg, and a mean bodyweight of 85.35 kg. The single-ply category includes 76,681 participants, with an average personal best of 133.97 kg and a mean bodyweight of 84.89 kg. In the multi-ply category, there are 14,678 participants, with an average personal best of 157.23 kg and a mean bodyweight of 94.69 kg.

Across all equipment types, the mean weights lifted increase from the first to the third attempts, and the percentage of successful attempts decreases with each successive attempt. This indicates that while lifters attempt heavier weights in successive attempts, the success rate declines. Approximately 86% of participants in the raw category, 80% in the single-ply category, and 97% in the multi-ply category are male. The average age of participants is around 31.77 years for raw lifters, 32.32 years for single-ply lifters, and 32.20 years for multi-ply lifters. These statistics highlight key performance trends and demographic characteristics in competitive powerlifting, emphasizing differences in performance and success rates among different equipment types and attempts.

Personal best weights of lifters who have never participated in an official bench press competition are recorded as zero. In the empirical analysis, we focus on the second and third attempts and treat the realized outcome in the first attempt as the personal best for such lifters because the success probability in the first attempt is 86% for raw lifters, 77% for single-ply lifters, and 70% for multi-ply lifters.

[5] https://gitlab.com/openpowerlifting.

Table 2: Summary Statistics

Equipment		N	mean	sd	min	max
Raw	Male	175983	0.86	0.35	0.00	1.00
	Personal best	175983	124.39	58.77	0.00	310.00
	First attempt weight	175983	130.96	44.77	5.00	330.00
	Second attempt weight	175983	137.42	45.89	20.00	352.50
	Third attempt weight	175983	141.62	46.57	20.00	352.50
	Successful first attempt	175983	0.86	0.35	0.00	1.00
	Successful second attempt	175983	0.72	0.45	0.00	1.00
	Successful third attempt	175983	0.40	0.49	0.00	1.00
	Best attempt	169111	137.97	46.25	0.00	325.00
	Age	175983	31.77	11.22	13.00	69.00
	Bodyweight	175983	85.35	20.37	24.90	240.00
Single-ply	Male	76681	0.80	0.40	0.00	1.00
	Personal best	76681	133.97	80.06	0.00	402.50
	First attempt weight	76681	156.16	64.67	5.00	445.00
	Second attempt weight	76681	162.82	65.51	20.00	445.00
	Third attempt weight	76681	168.05	66.65	20.00	445.00
	Successful first attempt	76681	0.77	0.42	0.00	1.00
	Successful second attempt	76681	0.65	0.48	0.00	1.00
	Successful third attempt	76681	0.40	0.49	0.00	1.00
	Best attempt	70756	160.21	64.68	0.00	445.00
	Age	76681	32.32	12.93	13.00	69.00
	Bodyweight	76681	84.89	23.19	30.50	245.00
Multi-ply	Male	14678	0.97	0.18	0.00	1.00
	Personal best	14678	157.23	95.59	0.00	425.00
	First attempt weight	14678	197.10	63.60	25.00	480.00
	Second attempt weight	14678	205.88	64.64	30.00	500.50
	Third attempt weight	14678	212.12	65.72	30.00	520.00
	Successful first attempt	14678	0.70	0.46	0.00	1.00
	Successful second attempt	14678	0.57	0.49	0.00	1.00
	Successful third attempt	14678	0.35	0.48	0.00	1.00
	Best attempt	12864	201.43	63.12	0.00	430.00
	Age	14678	32.20	10.10	13.00	69.00
	Bodyweight	14678	94.69	19.65	34.40	207.80

Sources: The OpenPowerlifting database. We also observe Wilks score and other relative strength metrics, and rankings of placement within the competition historical rankings and records used for robustness check.

2.2 Game setting

The objective of each lifter is to lift the maximum weight possible from a prone position on a flat bench to improve their own rank. In case of a tie (same weight lifted), the lighter lifter or the lifter who achieved the weight first (depending on the federation's rules) is ranked higher. Competitors are divided into categories based on weight class, age class, equipment class, and gender to ensure fair competition.[6]

Competition Structure Competitors declare their opening weight (first attempt) before the competition starts. The declared weights determine the initial lifting order. Lifters are arranged in ascending order based on their declared opening attempts. That is, the lifter with the lightest weight goes first, followed by the next lightest, and so on.

Each lifter has three attempts.[7] Each attempt is judged based on control, stability, and completion of lifting. A lift is considered successful if the lifter adheres to all the rules and completes the lift as per the judge's commands from the viewpoints of two of three referees. After completing an attempt, the lifter must declare the weight for their next attempt within a specific time frame (usually 1 minute after their attempt). Once a weight is declared, it generally cannot be decreased, only increased. The order of lifters is adjusted after each round of attempts based on the declared weights for the next attempt, again proceeding from lightest to heaviest. This ensures that the competition is efficient and fair.

Concretely, in the first attempt, all lifters complete their first attempt in the sequential order of the lightest to heaviest declared weights. In the second attempt, the order is recalculated based on the declared weights for the second attempt. Lifters who declared lighter weights for their second attempt will lift first. In the third attempt, the order is again recalculated for the third attempt based on the new declared weights. If a lifter fails an attempt, they can choose to reattempt the

[6] See details in the Internatinal Powerlifting Federation (IPF) Technical Rules Book.

[7] Lifting Procedure for each lifter at each attempt is officially divided into the following.

1. Setup: The lifter lies on their back on the bench, with feet flat on the floor or on the bench's footrests, ensuring contact with the bench throughout the lift.
2. Grip: The lifter grips the barbell, usually slightly wider than shoulder-width apart.
3. Unracking: With the help of spotters if needed, the lifter unracks the barbell and holds it with arms fully extended above their chest.
4. Lowering: The barbell is lowered in a controlled manner to touch the chest, ensuring it is stable and paused for a moment.
5. Press Command: The judge gives a "Press" command once the barbell is motionless on the chest. The lifter then presses the barbell back to the starting position with arms fully extended.
6. Rack Command: Upon completion, and with the barbell in a stable position, the judge gives the "Rack" command, signaling the lifter to return the barbell to the rack.

same weight or increase it for their next attempt. The order will still be based on the declared weight for the next attempt, regardless of whether the previous attempt was successful.

Each lifter's highest successful attempt is recorded as their final score. If two lifters achieve the same highest lift, the lighter lifter or the lifter who achieved the weight first (depending on the federation's rules) ranks higher.

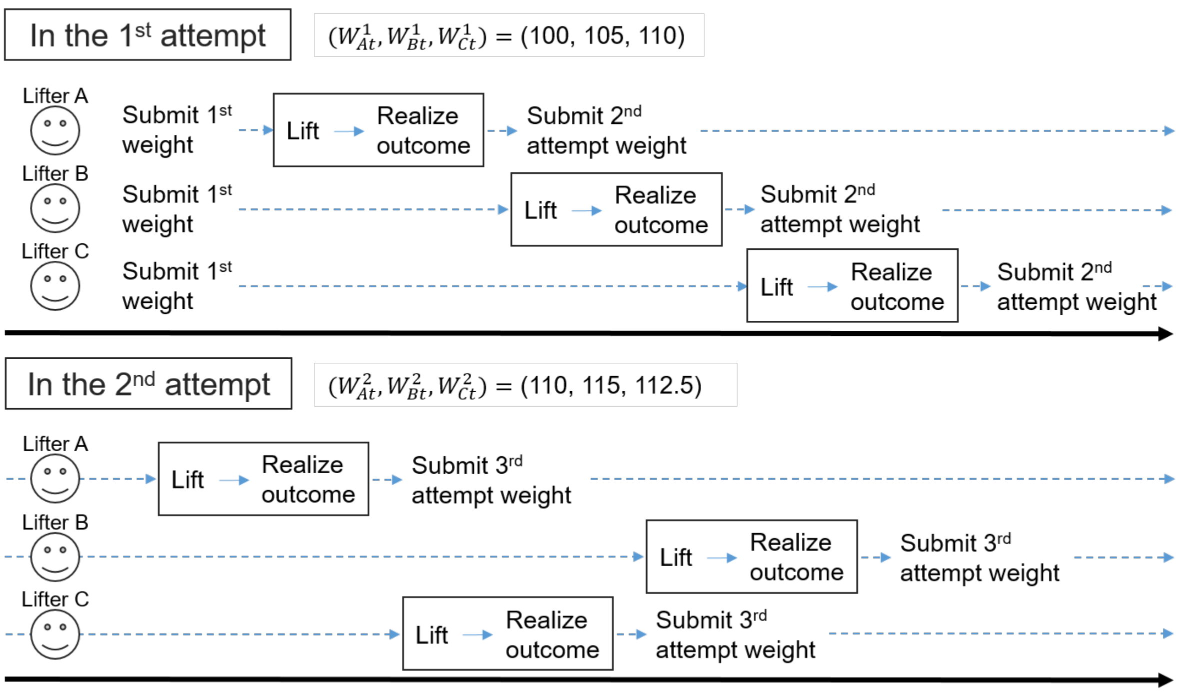


Figure 1: The Structure of the First and Second Attempts: Three Lifters Case

Notes: The box means that the player appears on the stage. W^j_{it} is lifter i's attempt weight in j-th attempt in competition t.

Example of Attempt Order: To highlight the available information of each lifter at each attempt, consider a competition with three lifters (A, B, and C). The timeline of the first and second attempts is shown in Figure 1. For opening attempts, lifters A, B, and C declare 100 kg, 105 kg, and 110 kg before the competition. Then, the order will be A, B, and C. Lifter A attempts 100 kg then the outcome is realized. Next, lifter B attempts 105 kg. At the same time, lifter A declares the next attempt weight 110 kg in one minute conditional on A's own first outcome and B and C's attempt weights before B's outcome is realized because lifter B is trying 105 kg at that time. Lifter B's outcome is realized. Next, lifter C attempts 110 kg. At the same time, lifter B declares the next attempt weight 115 kg in one minute knowing B's own first outcome, A's outcome and next attempt, and C's attempt weight before C's outcome is realized because lifter C is trying 110 kg at that time. Lifter C's outcome is realized. Lifter C declares the next attempt weight 112.5 kg in one minute knowing A and Bs' outcomes, their next attempts, and C's own first outcome. For the second attempts, the new order will be A (110 kg), C (112.5 kg), B (115 kg). After the same procedure, the new order for the third attempts, will be similarly determined by the declared weights at the second attempts.

2.3 Exogenous pressure

The above sequential game structure in which each player does not know the subsequent attempts and outcomes provides exogenous variations to the choice of the attempt weight and the success of lifting the attempt weight, which is analogous to the lottery choice and realized gain of the lottery. We focus on the moves of the closest rivals to each lifter, that is, his lower rank and higher rank rival lifters, which are critical to finalize his rank in the competition.

The choice of attempt weight In the choice of attempt weight at the second attempt, first, each lifter knows the first attempt outcome and the second attempt weight of his one lower rank rival. These are uncorrelated with the lifter's unobservable characteristics, such as his body condition on the competition date, because the rival declares his second attempt weight before observing the outcome of the lifter's second attempt, which—if observable—could serve as a proxy for the lifter's condition. The exogenous pressure affects the risk of being turned around by one lower rank rival, that is, the risk of loss. Second, each lifter expects the second attempt weight of his one higher rank rival, although this value is not yet observed. We assume that each lifter can make a prediction of a higher-ranked rival's action based on information about the rival's past attempts and a rich set of covariates.[8] Because these predictions are based solely on observable characteristics, they are independent of the lifter's own unobserved factors, such as temporary performance conditions. As the first attempt weight of his one higher rank rival is heavier than his current best weight, it is more difficult to turn around the rival. The exogenous pressure affects the risk of challenging turning around his one higher rank rival, that is, the risk of gain.

The success of lifting the attempt weight In the second attempt of lifting the attempt weight, each lifter knows the first and second attempt outcomes of his one lower rank rival. These are uncorrelated with the lifter's unobserved characteristics, such as his body condition on the competition date, because the lower-ranked rival completes both attempts without observing the lifter's second outcome. The exogenous pressure affects the risk of being turned around by one lower rank rival, that is, the risk of loss. If his second attempt fails, he is turned around by the

[8] The assumption is supported from our data in Section 7.2. Strategic reasoning in intermediate weight selections is also inherently limited, as each subsequent attempt must exceed the current attempt. While incorporating dynamic and strategic considerations is theoretically appealing, doing so introduces significant complexity and falls beyond the scope of our empirical analysis.

rival. Second, each lifter also knows the second attempt weight of his one higher rank rival. This declared weight is uncorrelated with the lifter's unobserved characteristics, because at the time of declaration, the higher-ranked rival has not yet observed the lifter's second outcome. If his second attempt is successful, he has more chances to turn around the rival. The exogenous pressure affects the risk of challenging turning around his one higher rank rival, that is, the risk of gain. Note that the pressure matters only in the lifting stage.

2.4 Data pattern

We illustrate data patterns of the choice of attempt weight and the success probability of the attempt weight conditional on the above exogenous pressure. For illustration, we show the case of the most popular competition category (Male, Raw, 24-39 age class). The data pattern is prevalent in the other competition categories. We omit the data pattern for the first bench press attempts because the success probability at that stage is more than 75%.

Attempt weight, success probability, and pressure Figure 2 displays success probabilities for second bench press attempts across different weight classes, showing the highest success rates when the attempted weight is slightly below the lifter's personal best. Across almost all classes, success peaks around a distance of zero, with success probabilities typically ranging from 0.75 to 1.00 at this point. As the attempted weight deviates from the best, success rates drop significantly, often falling below 0.25 at more extreme deviations, particularly for heavier attempts. In heavier weight classes (120 kg and 120+ kg), the range of successful attempts is slightly broader, but the general trend of declining success with larger deviations remains consistent across all weight categories. While both pressured ("turning around" or "turned around") and non-pressured groups follow similar patterns, the pressured group generally maintains slightly higher success probabilities, particularly near the lifters' personal best. However, variations exist across different weight categories, with some distances exhibiting no clear advantage for the pressured group.

Figure 3 illustrates more distinct patterns for third bench press attempts. Compared to the second attempt, success rates in the third attempt are noticeably lower across all weight classes. While success rates during the second attempt peaked between 0.75 and 1.00 near the lifters' personal best, the third attempt generally shows lower peak success rates, ranging between 0.5 and 0.8. Additionally, the decline in success rates as lifters deviate from their personal best is more pronounced in the third attempt, with success probabilities frequently dropping below 0.25 at larger deviations. The distinction between the "turning around" groups (0 and 1) remains visible, though the overall lower success rates make the difference less pronounced in the third attempt. Overall, lifters appear to struggle more in the third attempt, particularly when attempting weights significantly different from their personal best, indicating a notable drop in success probability compared to the second attempt.

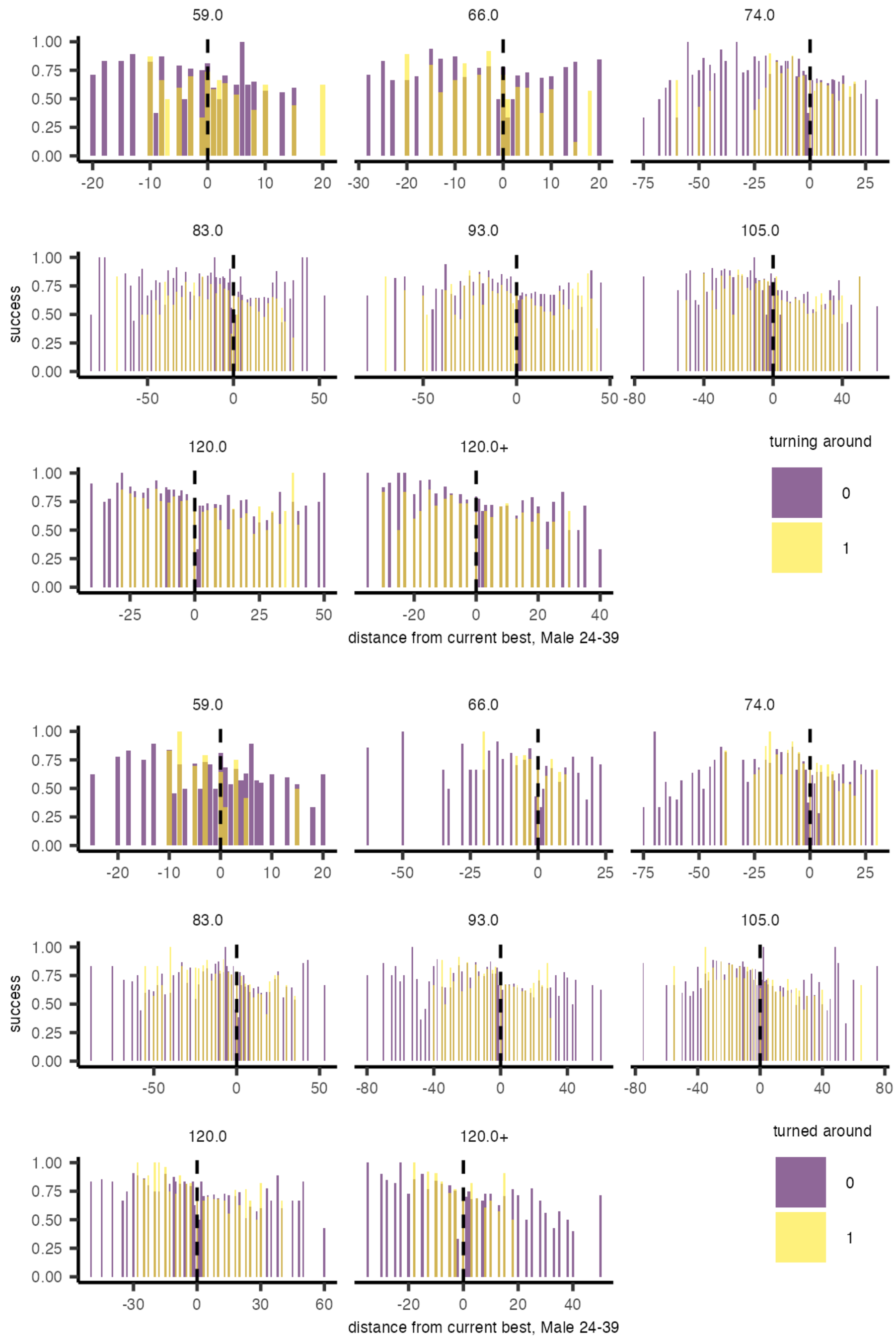


Figure 2: Success Rate Conditional on Pressures at Second Attempt (Male, Raw, 24-39 age class)
Notes: The distance from the current best was rounded to the nearest integer. Distance categories with five or fewer lifters were excluded from the plot to avoid skewing the success probabilities to 0 or 1.

In summary, the data suggests that when lifters face pressure in critical situations—such as attempting to improve their rank—they tend to choose more challenging weights. However, unlike the second attempt, where pressured lifters often maintain higher success rates, the third attempt

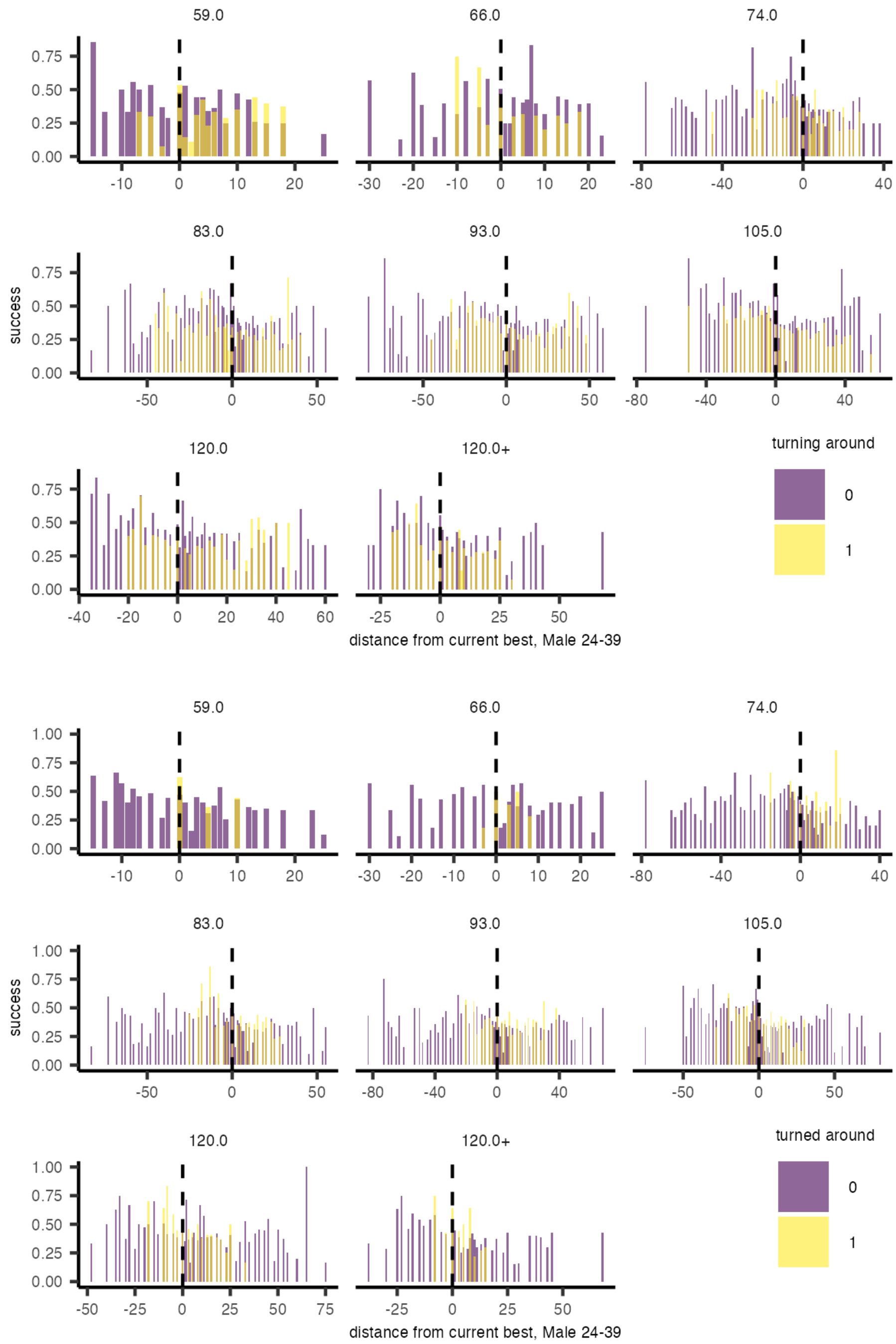


Figure 3: Success Rate Conditional on Pressures at Third Attempt (Male, Raw, 24-39 age class)
Notes: The distance from the current best was rounded to the nearest integer. Distance categories with five or fewer lifters were excluded from the plot to avoid skewing the success probabilities to 0 or 1.

shows a more substantial decline in overall success probabilities, suggesting increased difficulty in securing successful lifts under pressure.

Who are the rivals? We examine the pressure exerted by rivals during competition. A natural question arises: who constitutes a rival for each lifter within a competition? Table 3 illustrates the distribution of rank changes for lifters between their second and third attempts. The majority of lifters maintain their rank, as shown by the high proportion of zero rank changes (67% in the second attempt and 72% in the third attempt). A smaller percentage of lifters experience a rank increase (+1) between attempts (14% in the second and 10% in the third), while the proportion of those gaining two or more ranks is notably lower (5% in the second and 3% in the third). Similarly, lifters dropping one rank (−1) account for 8% in the second attempt and 9% in the third, with even fewer dropping two or more ranks (5% and 6%, respectively). Based on this distribution, we focus on the immediate competitors, specifically the lifter ranked directly below and the one ranked directly above, as these rivals most significantly influence rank changes.

Table 3: Distribution of Rank Changes

Changes in ranking	2nd	3rd
≤ -2	0.05	0.06
-1	0.08	0.09
0	0.67	0.72
$+1$	0.14	0.10
$+2 \leq$	0.05	0.03

Notes: We compute the distribution of rank changes using all achieved outcomes of all lifters in our data.

3 Theoretical prediction

In this section, we derive empirical predictions based on expected utility theory and prospect theory.[9] The choice of an attempt weight is analogous to a binary lottery choice drawn from a set of lotteries $(w, q(w))$, where w represents the attempt weight and $q(w) \in [0, 1]$ denotes the probability of success. We assume that the success probability is decreasing in weight, i.e., $q'(w) < 0$. Following Tversky and Kahneman (1992), we adopt a rank-dependent value function $v(\cdot)$ with reference point r defined as

$$v(x) = \begin{cases} (x-r)^{\alpha} & \text{if } x \geq r \\ -\lambda(r-x)^{\alpha} & \text{if } x < r, \end{cases}$$

where $0 < \alpha \leq 1$ and $\lambda > 1$ capture diminishing sensitivity—concave curvature in the gain domain and a convex curvature in the loss domain—and loss aversion, respectively. Here, x denotes the

[9] See the survey of O'Donoghue and Sprenger (2018) and DellaVigna (2018) for reference.

rank of lifter i at the end of the stage and r is the intermediate rank of i before this stage. In our application, the change in rank $(x - r)$ takes values in $\{-1, 0, 1\}$.

3.1 Lifting stage

Consider the attempt and lifting stages backward. We do not incorporate strategic decisions across stages to avoid complications making the situation intractable, but this would be an interesting research avenue. As noted earlier, the change in ranking takes values in $\{-1, 0, 1\}$, meaning that α does not affect this stage. Let $q(w_H)$ denote the ex-ante probability that the higher-ranked rival successfully lifts the attempted weight w_H, which is unknown to lifter i at the time of their own attempt. Similarly, let $q(w_L)$ denote the ex-ante probability that the lower-ranked rival succeeds in lifting the attempted weight w_L, which is also unknown to lifter i at the attempt stage.

Table 4: Utility Tuple $(v_1(x), (v_2(x), v_3(x)))$

Lower rival's outcome turning around i	Higher rival's attempt is turned around by i	
	No	Yes
No	$(0, (0, 0))$	$(0, (0, 1))$
Yes	$(-\lambda, (0, 0))$	$(-\lambda, (0, 1))$

Table 4 describes the utility tuple $(v_1(x), (v_2(x), v_3(x)))$ conditional on four scenarios determined by pressure from lower and higher rivals, where $v_1(x)$ is the utility when lifter i's attempt weight x fails, and $(v_2(x), v_3(x))$ is the utility when lifter i's attempt is successful and the higher rival's attempt either succeeds or fails. For simplicity, we assume $\alpha = 1$, which does not affect our prediction. If there is no pressure from either lower or higher rivals (i.e., (No, No)), the current lifting attempt does not change lifter i's rank whether successful or not, meaning $(v_1(x), (v_2(x), v_3(x))) = (0, (0, 0))$. If there is pressure only from a lower rival (i.e., (Yes, No)), lifter i experiences disutility $-\lambda(< -1)$ upon failure, but zero otherwise. If there is pressure only from a higher rival (i.e., (No, Yes)), lifter i gains 1 if the higher rival fails, with the probability of $1 - q(w_H)$. If there is pressure from both lower and higher rivals, lifter i experiences disutility $-\lambda(< -1)$ upon failure, gains 0 when both lifter i and the higher rival succeed, and gains 1 if the higher rival fails, with the probability of $1 - q(w_H)$. Based on these scenarios, lifter i has the strongest incentive to make an effort to avoid loss and gain when there is pressure from his lower and higher rivals. Based on these scenarios, lifter i has the strongest incentive to exert effort to avoid loss and seek gains when under pressure from both lower- and higher-ranked rivals. If $\lambda > 1$, the incentive to exert effort to avoid loss is further amplified.

3.2 Attempt stage

We now examine the attempt stage, focusing on how lifter i's choice of attempt weight is influenced by their competitors. For simplicity, we analyze the effects of the lower and higher rivals separately. This distinction is justified by the empirical analysis, where both sources of pressure are incorporated simultaneously into the model. By conditioning on the influence of one competitor while examining the effect of the other, we can isolate their respective impacts on the lifter's decision-making.[10]

3.2.1 Response to a lower rival

Let w_L denote the attempt weight of the lower rival and let y_L and y_i be the best outcome weights from earlier attempts within the competition for the lower rival and lifter i, respectively. The inequality conditions $y_L < y_i$, determined by rank order, and $y_L \leq w_L$ and $y_i \leq w_i$, meaning that the outcome weight must not exceed the corresponding attempt weight, must hold, given by the current competition rule. We consider three cases:[11]

Case 1: $w_L > w_i \geq y_i$. Even if lifter i succeeds, his attempt weight w_i remains below the lower rival's w_L; thus, his rank depends solely on the lower rival's success probability $q(w_L)$. The expected utility is

$$\begin{aligned} EU|_{w_L > w_i \geq y_i} &= [1 - q(w_L)] \cdot 0 + q(w_L) \cdot [-\lambda] \\ &= -\lambda q(w_L) \leq 0. \end{aligned}$$

Case 2: $w_i > w_L > y_i$. In this case, if lifter i succeeds his rank remains unchanged; however, if he fails and the lower rival succeeds, he incurs a loss. Thus,

$$\begin{aligned} EU|_{w_i > w_L > y_i} =& q(w_i) \cdot 0 + [1 - q(w_i)]\,[1 - q(w_L)] \cdot 0 + [1 - q(w_i)]\, q(w_L) \cdot [-\lambda] \\ =& -\lambda\, [1 - q(w_i)]\, q(w_L) \leq 0. \end{aligned}$$

Case 3: $w_i \geq y_i > w_L$. Here, even if the lower rival succeeds, there is no change in rank; hence,

$$EU|_{w_i \geq y_i > w_L} = 0.$$

[10] While it is possible to construct a model that simultaneously accounts for both rivals, doing so significantly increases the complexity of the framework. To maintain analytical tractability and improve interpretability, we present the separate analyses in the main text. A more comprehensive model incorporating both rivals jointly is provided in Appendix A.1.

[11] If $w_i = w_L$, the lifter with the lighter bodyweight receives the higher ranking. Such tie-weight situations are categorized into the three cases described above.

Since w_L is exogenously determined from the viewpoint of lifter i, we obtain the ordering

$$EU\ |_{w_i \geq y_i > w_L} \geq EU\ |_{w_i > w_L > y_i} \geq EU\ |_{w_L > w_i \geq y_i}.$$

Moreover, note that

$$\frac{\partial EU\ |_{w_i > w_L > y_i}}{\partial w_i} = \lambda q(w_L) q'(w_i) \leq 0,$$

since $q'(w_i) < 0$. Therefore, lifter i will declare an attempt weight that is slightly heavier than that of the lower rival. Note that the value of λ does not directly affect the level of the chosen attempt weight. As long as $\lambda > 0$, the prediction remains informative and aligned with observed behavior.

3.2.2 Response to a higher rival

Let w_H denote the declared weight of the higher rival. Although this is not observable to lifter i's attempt stage, we treat this as highly predictable information to lifter i.[12] Additionally, let y_H be the higher rival's best outcome weights up to the previous stage. The following cases arise:

Case 1: $w_H \geq y_H > w_i$. When lifter i's attempt weight w_i is below the higher rival's outcome up to the previous stage, there is no change in rank, so

$$EU|_{w_H \geq y_H > w_i} = 0.$$

Case 2: $w_H > w_i > y_H$. In this case, if lifer i succeeds and the higher rival fails, he overtakes the higher rival; otherwise, his rank remains unchanged. Hence,

$$\begin{aligned} EU|_{w_H > w_i > y_H} =& q(w_i)\,[1 - q(w_H)] \cdot 1 \\ =& q(w_i)\,[1 - q(w_H)] \geq 0. \end{aligned}$$

Case 3: $w_i > w_H \geq y_H$. By declaring a weight higher than the higher rival's, lifter i secures the rank improvement if he succeeds. Thus,

$$\begin{aligned} EU|_{w_i > w_H \geq y_H} =& q(w_i) \cdot 1 + [1 - q(w_i)] \cdot 0 \\ =& q(w_i) \geq 0. \end{aligned}$$

Let w_i^+ denote a choice such that $w_i > w_H$ and w_i^- denote a choice with $w_i < w_H$. Comparing the expected utilities, we have:

$$EU|_{w_i > w_H \geq y_H} > EU|_{w_H > w_i > y_H} \Leftrightarrow \frac{q(w_i^+)}{q(w_i^-)} > 1 - q(w_H),$$

[12] Using our data, we discuss the predictability of higher rival's attempt weight given observable information at lifter i's attempt stage in Section 7.

noting that $q(w_i^+) < q(w_i^-)$ since higher attempt weight implies a lower success probability and therefore $q(w_i^+)/q(w_i^-) \in (0, 1)$.

Given w_H is fixed, if the higher rival's success probability $q(w_H)$ is sufficiently high and/or if the success probability $q(w_i)$ does not change significantly whether lifter i chooses a weight that exceeds w_H or one that remains below w_H, then we obtain

$$EU|_{w_i > w_H \geq y_H} \geq EU|_{w_H > w_i > y_H} \geq EU|_{w_H \geq y_H > w_i}.$$

Otherwise, if $q(w_i)$ declines steeply when w_i exceeds w_H, then the reverse ordering holds:

$$EU|_{w_H > w_i > y_H} \geq EU|_{w_i > w_H \geq y_H} \geq EU|_{w_H \geq y_H > w_i}.$$

Furthermore, note that

$$\frac{\partial EU|_{w_i > w_H \geq y_H}}{\partial w_i} = q'(w_i) < 0, \text{ and } \frac{\partial EU|_{w_H > w_i > y_H}}{\partial w_i} = q'(w_i)\left[1 - q(w_H)\right] \leq 0.$$

Therefore, lifter i will declare a weight that is slightly heavier than either the higher rival's (expected) declared weight or the higher rival's best outcome up to the previous stage (i.e., y_H), depending on the higher rival's success probability $q(w_H)$ and on the sensitivity of $q(w_i)$ to changes in w_i.

4 Estimation

4.1 Choice of attempt weight

As the first empirical exercise, we employ a linear regression model to estimate the effect of pressure on the choice of attempt weight. We regress the outcome on the observed characteristics as follows:

$$\tilde{W}_{it}^k = X_{it}\beta + Z_{it}^k\gamma + \varepsilon_{it}, \tag{1}$$

where $\tilde{W}_{it}^k$ is the difference between lifter i's attempt weight compared to his current best in competition t at a k-th attempt, X_{it} is observed characteristics of lifter i and competition t including gender, body weight, number of competition experiences, a dummy variable for first participation, and fixed effects for competition t's equipment category, age class, division, weight class, and federation. It also includes a dummy variable indicating whether the lifter shares the same declared attempt weight with another competitor, potentially causing ambiguity in the lifting order due to unresolved tie-breaking rules, and another dummy variable capturing mismatches between the actual lifting order and the interim ranking order, which may affect the set of observable information about rivals. Z_{it}^k is a pressure variable during attempt defined later, ε_{it} is assumed to be an i.i.d. error, and β and γ are vectors of coefficient parameters of X_{it} and Z_{it}^k. Large $\tilde{W}_{it}^k$ implies his choosing a more challenging attempt weight. Our primary interest lies in γ, that is, the sensitivity to pressure.

The pressure variables, Z_{it}^k, which are exogenous due to the sequential game setting, represent the difference between the lifter's current realized outcome and the attempted weight of the lower-ranked competitor at the next attempt, and the difference between the lifter's current realized outcome and the expected attempt weight of the higher-ranked competitor predicted by the linear regression model. The actual higher-ranked attempt weight should not be used because it is not realized at lifter i's attempt, although it must be predictable. We discuss the predictability issues and how to correct prediction errors, in particular, for constructing standard errors via bootstrap in Section 7. These variables capture the potential for the lifter's rank to change by overtaking or being overtaken by the rivals.

4.2 Success probability

As the second empirical exercise, we use a linear probability model to estimate the probability of successfully lifting the attempt weight. We regress the outcome on the observed characteristics as follows:

$$Y_{it} = X_{it}\beta + \tilde{Z}_{it}^k\gamma + \tilde{W}_{it}^k\delta + \eta_{it}, \tag{2}$$

where Y_{it} is whether the attempt is successful ($Y_{it} = 1$) or not ($Y_{it} = 0$), $\tilde{Z}_{it}^k$ is a pressure variable during lifting, η_{it} is assumed to be an i.i.d. error, and δ represents the coefficient for the difference between lifter i's attempt weight and his current best. Note that $\tilde{W}_{it}^k$, the choice of attempt weight, may be correlated with unobserved body conditions in η, potentially causing endogeneity issues. To address this, we employ a two-stage least squares (2SLS) regression, using Equation (1) as the first-stage regression, with the exogenous pressure variables during the attempt, Z_{it}^k, serving as instrumental variables (IV).

The pressure variable $\tilde{Z}_{it}^k$ during the lift is equal to one if the attempt involves overtaking a higher-ranked rival or being overtaken by a lower-ranked rival, and zero otherwise. These variables capture the potential for rank changes through overtaking or being overtaken.

Table 5: Regression of the Difference between the Second and Third Attempt Weight Compared to the Current Best on Pressure

	(1)	(2)
Dependent Variable	W_{it}^2-(best)	W_{it}^3-(best)
Male	-1.279	3.583
	(0.409)	(0.595)
Body weight	0.269	0.373
	(0.023)	(0.035)
Num experience	0.306	0.325
	(0.085)	(0.112)
1(first participation)	32.122	33.623
	(1.507)	(1.633)
Pressure, lower rival, 2nd	0.106	
	(0.009)	
Pressure, higher rival, 2nd	0.449	
	(0.010)	
Pressure, lower rival, 3rd		0.057
		(0.006)
Pressure, higher rival, 3rd		0.409
		(0.011)
Control	X	X
Num.Obs.	246521	246521

Notes: We control gender, body weight, equipment category, age-class, division, weight-class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking. The standard errors in the brackets are clustered at federation categories. W_{it}^2 and W_{it}^3 are lifter i's attempt weights in the second and third attempts in competition t. Pressure from lower rival at 2nd is (lower rival 2nd attempt) - (his 1st outcome). Pressure from lower rival at 3rd is (lower rival 3rd attempt) - (his 2nd outcome). Pressure from higher rival at 2nd is (higher rival 2nd attempt) - (his 1st outcome). Pressure from higher rival at 3rd is (higher rival 3rd attempt) - (his 2nd outcome).

5 Results

5.1 Choice of attempt weight

Table 5 presents the regression results for the difference between the second and third attempt weights compared to the current best, incorporating various pressure variables. Male lifters exhibit mixed responses, with a statistically significant negative coefficient for the second attempt (–1.279) and a positive coefficient for the third attempt (3.583). This suggests that male lifters adopt a conservative approach in their second attempt but take greater risks in their third attempt, a pattern consistent with the literature on gender differences in risk-taking. Body weight and experience are positively associated with higher attempt weights in both attempts, indicating that heavier and more experienced lifters generally select heavier weights. The positive coefficients for first participation (32.122 and 33.623) suggest that first-time competitors attempt significantly higher weights relative to their current best.

For the second attempt, pressure from both lower- and higher-ranked rivals has a statistically significant positive effect (0.106 and 0.449, respectively), suggesting that the presence of competitive pressure encourages lifters to attempt heavier weights. In the third attempt, pressure from lower-ranked rivals continues to have a positive effect (0.057), though its magnitude is smaller than in the second attempt. Meanwhile, pressure from higher-ranked rivals remains strongly positive (0.409), reinforcing the idea that lifters attempt heavier weights when their higher-ranked competitors perform well. The persistence of positive coefficients in the third attempt suggests that lifters under strong competitive pressure, particularly from higher-ranked rivals, do not necessarily adopt a conservative strategy but instead continue to take risks, likely in an effort to improve their final ranking.

5.2 Success probability of lifting the attempt weight

Table 6 provides insights into how pressure influences the success probabilities of the second and third lifting attempts. In Column 1, the pressure from being turned around in the second attempt has a small but positive effect on success probability (0.014), suggesting that lifters may exert additional effort to avoid losing rank. However, the coefficient is modest, indicating a limited influence of loss aversion in this context. Conversely, the pressure of turning around a higher-ranked lifter in the second attempt has a slightly negative coefficient (–0.012), implying that lifters attempting to overtake a higher rival may face increased difficulty in execution.

For the third attempt, the pressure of being turned around remains positively associated with success probability (0.033), while the pressure of turning around a higher-ranked rival has a negative coefficient (–0.038). This suggests that lifters are more likely to succeed when pressured from below but face greater challenges when attempting to surpass a higher-ranked competitor.

Table 6: Regression of Success Probability of Second and Third Attempts on Pressure

	(1)	(2)	(3)	(4)
Dependent Variable	1(success 2nd)	1(success 3rd)	1(success 2nd)	1(success 3rd)
Male	0.000	0.006	0.002	0.008
	(0.006)	(0.006)	(0.006)	(0.006)
Body weight	-0.001	-0.001	-0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Num experience	0.001	-0.001	0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)
1(first participation)	-0.004	-0.005	0.014	0.011
	(0.003)	(0.003)	(0.004)	(0.005)
W_{it}^2-(best)	-0.001		-0.001	
	(0.000)		(0.000)	
W_{it}^3-(best)		0.000		-0.001
		(0.000)		(0.000)
1(Turned around, 2nd)	0.014		0.013	
	(0.003)		(0.003)	
1(Turning around, 2nd)	-0.012		-0.005	
	(0.004)		(0.005)	
1(Turned around, 3rd)		0.033		0.032
		(0.003)		(0.003)
1(Turning around, 3rd)		-0.038		-0.034
		(0.005)		(0.006)
Control	X	X	X	X
IV			X	X
Num.Obs.	246521	246521	246521	246521
R2	0.048	0.023	0.046	0.022
R2 Adj.	0.044	0.019	0.042	0.017
RMSE	0.45	0.48	0.45	0.48

Notes: We control gender, body weight, equipment category, age-class, division, weight-class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking. The standard errors in the brackets are clustered at federation categories.

Columns 3 and 4, which present the results of the IV regression, show consistent patterns with slightly reduced magnitudes and statistical significance.

Overall, these findings highlight the role of pressure across attempts, with loss aversion playing a key role and overtaking higher-ranked rivals remaining particularly challenging. The asymmetry—where upward pressure consistently lowers success probabilities, while downward pressure has neutral or slightly positive effects—is consistent with the loss-averse utility structure assumed in the theoretical framework, whereby individuals exert more effort under pressure from lower-ranked rivals to avoid losses.[13]

5.3 Heterogeneity

Tables 7 and 8 show how responses to pressure vary by gender, experience, and historical rivalry frequency. Male lifters respond more strongly to both lower- and higher-ranked rivals (0.104 and 0.455, respectively) than female lifters (0.068 and 0.257), particularly under upward pressure. More experienced lifters are more responsive to higher-ranked rivals, highlighting the role of accumulated competitive cues. A higher historical rivalry frequency—defined as the number of prior encounters with a rival—is associated with greater responsiveness, suggesting that familiarity influences attempt selection. These trends indicate that male, experienced lifters facing well-known rivals take greater risks.

For success probabilities, gender differences vary by pressure direction. When under pressure from lower-ranked rivals—i.e., at risk of being overtaken—male lifters show higher success probabilities in both second (0.015) and third attempts (0.032). Female lifters, by contrast, show little to no benefit in the second attempt (–0.003) but exhibit a positive effect in the third (0.034), suggesting that downward pressure converges across genders in later stages.

In contrast, when attempting to overtake higher-ranked rivals, both genders experience reduced success probabilities, slightly more negative for female lifters (–0.039 vs. –0.034 in the third attempt). This suggests that upward pressure imposes psychological and performance costs for most lifters, with gender gaps persisting, while motivational effects of downward pressure are more stage-dependent and gender-convergent.

Experience plays a limited role in moderating these effects, with small but significant coefficients. Historical rivalry frequency is linked to higher success under downward pressure (0.012 in the second attempt; 0.028 in the third), but lower success under upward pressure (–0.007 in the third). This suggests familiarity with lower-ranked rivals helps manage performance anxiety, whereas familiarity with higher-ranked rivals may heighten psychological stress. Overall, these results underscore the complex interplay between gender, experience, and competitive history in shaping risk-taking and execution under pressure.

[13] This pattern is also observed in other competitive settings, such as marathons (Allen *et al.* 2017).

Table 7: Attempt Heterogeneity on Pressure

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	$W_{it}^{2}-$(best)			$W_{it}^{3}-$(best)		
(Pressure, lower rival)× 1(female)	0.068			-0.021		
	(0.015)			(0.026)		
(Pressure, lower rival)× 1(male)	0.104			0.056		
	(0.009)			(0.006)		
(Pressure, higher rival)× 1(female)	0.257			0.154		
	(0.010)			(0.015)		
(Pressure, higher rival)× 1(male)	0.455			0.417		
	(0.010)			(0.011)		
(Pressure, lower rival)× (Num experience)		0.004			0.001	
		(0.001)			(0.001)	
(Pressure, higher rival)× (Num experience)		0.031			0.032	
		(0.001)			(0.002)	
(Pressure, lower rival)× (Historical rivalry freq)			0.100			0.127
			(0.011)			(0.010)
(Pressure, higher rival)× (Historical rivalry freq)			0.095			0.095
			(0.012)			(0.015)
Control	X	X	X	X	X	X
Num.Obs.	247449	247449	247449	247438	247438	247438
R2	0.535	0.400	0.332	0.346	0.292	0.256
R2 Adj.	0.533	0.397	0.329	0.343	0.289	0.253

Notes: We control gender, body weight, equipment category, age-class, division, weight-class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking as in the main specification. The standard errors in the brackets are clustered at federation categories.

Table 8: Success Probability Heterogeneity on Pressure

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	1(success 2nd)			1(success 3rd)		
1(Turned around)× 1(female)	-0.003			0.034		
	(0.006)			(0.013)		
1(Turned around)× 1(male)	0.015			0.032		
	(0.003)			(0.004)		
1(Turning around)× 1(female)	-0.014			-0.039		
	(0.007)			(0.010)		
1(Turning around)× 1(male)	-0.003			-0.034		
	(0.006)			(0.006)		
1(Turned around)× (Num experience)		0.001			0.003	
		(0.000)			(0.001)	
1(Turning around)× (Num experience)		0.001			-0.002	
		(0.000)			(0.000)	
1(Turned around)× (Historical rivalry freq)			0.012			0.028
			(0.003)			(0.007)
1(Turning around)× (Historical rivalry freq)			-0.002			-0.007
			(0.004)			(0.004)
Control	X	X	X	X	X	X
IV	X	X	X	X	X	X
Num.Obs.	246521	246521	246521	246521	246521	246521
R2	0.046	0.046	0.046	0.022	0.021	0.021
R2 Adj.	0.042	0.041	0.041	0.017	0.016	0.016

Notes: We control gender, body weight, equipment category, age-class, division, weight-class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking as in the main specification. The standard errors in the brackets are clustered at federation categories.

6 Counterfactual

Individual responses to pressure influence the overall distribution of risk-taking, success probability, and expected outcomes. The unique structure of official bench press competitions provides an opportunity to disentangle these effects and compare alternative competition settings to the current format.

Using the estimated results, we first simulate the attempt weights and the success probability for each attempt of each player under actual pressure.[14] We then calculate the expected achieved weights, defined as the product of the predicted attempt weight and the success probability. These serve as benchmark outcomes under actual pressure conditions.

The first alternative competition setting assumes that players would have to simultaneously submit their planned attempt weights for all attempts before the first attempt and commit to the plan. This setting eliminates the possibility of pressure from rivals influencing weight attempts. While introducing this as a formal rule is unrealistic, such a commitment is common at the individual level. We refer to this scenario as the "no pressure during attempt" setting.

The second alternative competition setting posits that players could not observe the attempt weights and outcomes of their rivals after the competition begins. This removes the influence of sequentially updated outcomes from rivals on the success probability. Similar to the first scenario, formalizing this rule would be challenging, though such a commitment is feasible at the individual level. We refer to this scenario as the "no pressure during lifting" setting.

The third alternative competition setting combines the first two scenarios, creating a condition in which there would be no pressure during both the attempt and the lifting phases.

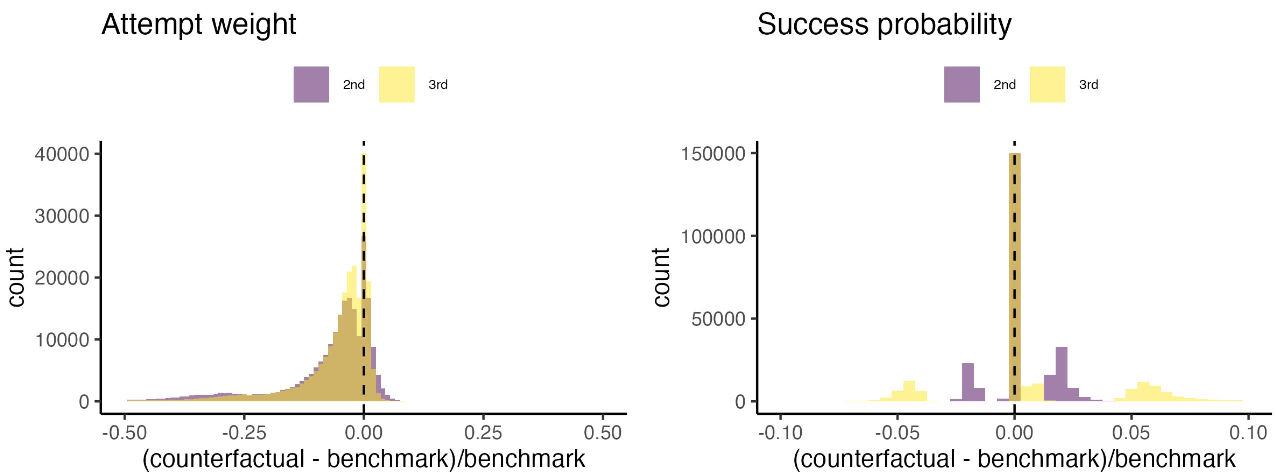
For these alternative competition settings, we simulate the attempt weights, the success probability, and the expected achieved weight for each player, holding the estimated coefficients of the pressure variables at zero.

6.1 Attempt and success probability

Panel (a) in Figure 4 shows the distribution of proportional changes in second and third attempt weights under the counterfactual without pressure during the attempt. Both distributions exhibit substantial deviations from zero, indicating that pressure has a strong influence on attempt weights. The third attempt distribution is slightly more concentrated around zero, but the overall shapes of the second and third attempt distributions are similar. These patterns suggest that pressure during the attempt significantly affects weight selection, with comparable impacts on second and third attempts.

Panel (b) in Figure 4 presents the distribution of proportional changes in the second and third

[14] Our regression results use the predicted attempt weight minus the current best as a dependent variable. We obtain simulated attempt weight by adding the current best to the predicted outcomes.



(a) Attempt

(b) Lifting

Figure 4: Counterfactual Attempt and Lifting

Notes: We use estimated coefficients in Table 5 and Columns (3) and (4) in Table 6.

attempt success probabilities from the benchmark to the counterfactual. For the second attempt, the distribution is relatively concentrated, with peaks around zero, indicating that some lifters experience modest gains or losses in success probability when pressure is removed. In contrast, the third attempt shows a more dispersed distribution with heavier tails, suggesting greater variability in how lifters respond to the absence of pressure. While a subset of lifters benefit, many experience reduced success. Overall, the removal of competitive pressure leads to mixed effects in both attempts, with more pronounced heterogeneity in the third.

6.2 Expected weight

Figure 5 presents the distribution of expected achieved weight differences for second and third attempts, comparing the conditions of "no pressure" during the attempt, lifting, or both.

In the second attempt, almost all counterfactual settings lead to lower expected outcomes, especially in the "no pressure in both" condition, where the distribution is clearly left-skewed. The "no pressure during lifting" case shows a sharper peak near zero, suggesting that many lifters would still achieve similar weights without pressure during execution.

In the third attempt, the distributions become more dispersed, particularly under "no pressure during attempt" and "no pressure in both" conditions. A small group under "no pressure during lifting" shows gains, but most lifters experience reduced outcomes. These patterns highlight substantial heterogeneity in pressure responses and reinforce the motivational role of real-time competition.

As practical advice, most lifters may benefit from adjusting their attempts in response to

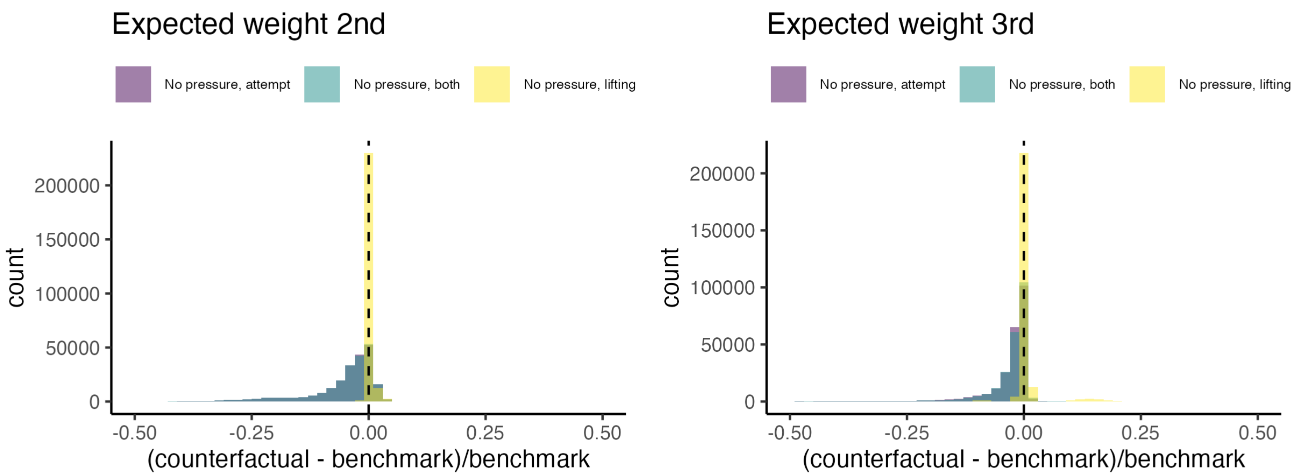


Figure 5: Counterfactual Expected Achieved Weight

Notes: We use estimated coefficients in Table 5 and Columns (3) and (4) in Table 6. Positive values indicate better performance under no pressure than under actual competition pressure.

competitive pressure, as removing pressure tends to reduce both attempted and achieved expected weights. However, reacting to pressure from rivals is not universally optimal across lifters. More broadly, individuals in sequential high-stakes settings should account for their own sensitivity to competitive pressure, recognizing that for many, performance deteriorates in its absence.

7 Robustness check

7.1 Choice of lifter's current best score

As our main outcome includes the lifter's current best, we need to take care of the construction. For example, lifters might consider the last 12 months best score as the current best and ignore the more past best score because older personal bests may not accurately reflect lifters' current abilities. Although we partly take care about the issues by controlling age-class, we need to check robustness of our reference point choice. We consider personal best over the more recent competition, that is, the personal best achieved within a certain recent period (e.g., the last 12 months).

Table 9 corresponds to Table 5 for the analysis of attempt weights using the lifter's current best within one year. The main findings remain robust: pressure from both lower- and higher-ranked rivals continues to have positive and significant effects on attempt weights in both the second and third attempts. While the coefficient on the male dummy changes sign in the second attempt, the overall patterns are consistent, reinforcing that lifters respond to competitive pressure, particularly from higher-ranked rivals.

Table 9: Regression of the Difference between the Second and Third Attempt Weight Compared to the Current Best within a Year on Pressure

	(1)	(2)
Dependent Variable	W_{it}^2−(best)	W_{it}^3−(best)
Male	0.528	5.785
	(0.324)	(0.476)
Body weight	0.151	0.254
	(0.031)	(0.035)
Num experience	-0.059	-0.125
	(0.057)	(0.067)
1(first participation)	29.646	30.688
	(1.287)	(1.344)
Pressure, lower rival, 2nd	0.092	
	(0.009)	
Pressure, higher rival, 2nd	0.483	
	(0.008)	
Pressure, lower rival, 3rd		0.043
		(0.005)
Pressure, higher rival, 3rd		0.427
		(0.010)
Control	X	X
Num.Obs.	230744	230744
R2	0.561	0.325
R2 Adj.	0.559	0.322

Notes: We control gender, body weight, equipment category, age-class, division, weight-class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking. The standard errors in the brackets are clustered at federation categories. W_{it}^2 and W_{it}^3 are lifter i's attempt weights in the second and third attempts in competition t. Pressure from lower rival at 2nd is (lower rival 2nd attempt) - (his 1st outcome). Pressure from lower rival at 3rd is (lower rival 3rd attempt) - (his 2nd outcome). Pressure from higher rival at 2nd is (higher rival 2nd attempt) - (his 1st outcome). Pressure from higher rival at 3rd is (higher rival 3rd attempt) - (his 2nd outcome).

Table 10: Regression of Success Probability of Second and Third Attempts on Pressure, the Current Best within a Year

	(1)	(2)	(3)	(4)
Dependent Variable	1(success 2nd)	1(success 3rd)	1(success 2nd)	1(success 3rd)
Male	0.003	0.008	0.005	0.010
	(0.007)	(0.006)	(0.007)	(0.007)
Body weight	-0.001	-0.001	-0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Num experience	0.002	0.000	0.002	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
1(first participation)	0.012	0.010	0.021	0.019
	(0.003)	(0.003)	(0.003)	(0.005)
W_{it}^2-(best)	-0.001		-0.001	
	(0.000)		(0.000)	
W_{it}^3-(best)		0.000		-0.001
		(0.000)		(0.000)
1(Turned around, 2nd)	0.012		0.012	
	(0.003)		(0.003)	
1(Turning around, 2nd)	-0.007		-0.003	
	(0.004)		(0.005)	
1(Turned around, 3rd)		0.033		0.032
		(0.004)		(0.004)
1(Turning around, 3rd)		-0.036		-0.033
		(0.005)		(0.006)
Control	X	X	X	X
IV			X	X
Num.Obs.	230744	230744	230744	230744
R2	0.043	0.022	0.042	0.021
R2 Adj.	0.038	0.017	0.037	0.016

Notes: We control gender, body weight, equipment category, age-class, division, weight-class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking. The standard errors in the brackets are clustered at federation categories.

Similarly, Table 10 corresponds to Table 6 for the analysis of success probabilities, utilizing the lifter's current best within a year. The main results are largely consistent with the primary specification. Upward pressure—especially attempts to overtake higher-ranked rivals—is associated with a higher likelihood of failure.

Overall, the alternative specification using the current best within a year confirms the key findings from the main analysis: competitive pressure affects both strategic weight selection and execution success, and these effects persist across time horizons.

7.2 Expected rivals' attempt weights

In our theoretical prediction in Section 3 and empirical exercises, we use the predicted attempt weight of lifter i's higher-ranked rival—unobservable to lifter i at the attempt stage. Although this approach involves prediction errors, assuming that the higher rival's attempt weight is completely unknown would ignore the pressure exerted by the higher-ranked rival, which plays a significant role in actual competition.

Table 11: Prediction of Attempt Weights Using Linear Regression

Attempt	Model	RMSE	R2
1st	Full	23.837	0.813
2nd	Full	4.214	0.994
2nd	Without 1st success	4.481	0.994
3rd	Full	3.450	0.996
3rd	Without 2nd success	4.191	0.995

Notes: All models include gender, body weight, equipment category, age class, division, weight class, federation, a dummy for first participation, number of competition experiences, and current best as predictors. They also include a dummy variable indicating whether the lifter shares the same declared attempt weight with another competitor—potentially causing ambiguity in the lifting order due to unresolved tie-breaking rules—and another dummy variable capturing mismatches between the actual lifting order and the interim ranking order, which may affect the set of observable information about rivals. In the full model for the 2nd attempt, both the attempt weight and the success of the 1st attempt are included as predictors, while in the "without 1st success" model, the success of the 1st attempt is excluded. Similarly, in the full model for the 3rd attempt, the attempt weight and the success of the 2nd attempts are used, while in the "without 2nd success" model, the success of the 2nd attempt is excluded. Predictive accuracy is assessed using 5-fold cross-validation.

Table 11 presents the Root Mean Squared Error (RMSE) and R^2 values for different prediction models of attempt weights using linear regression. Predictive accuracy is assessed through 5-fold cross-validation. All models include gender, body weight, equipment category, age class, division, weight class, federation, a dummy for first participation, number of competition experiences, and current best as predictors. They also include a dummy variable indicating whether the lifter shares the same declared attempt weight with another competitor—potentially causing ambiguity in the lifting order due to unresolved tie-breaking rules—and another dummy variable capturing mismatches between the actual lifting order and the interim ranking order, which may affect the set of observable information about rivals. In the full model for the 2nd attempt, both the attempt weight and the success of the 1st attempt are included as predictors, while in the "without 1st success" model, the success of the 1st attempt—unobservable when predicting the higher rival's 2nd attempt weight—is excluded. Similarly, in the full model for the 3rd attempt, the attempt weight and the success of both the 1st and 2nd attempts are used, whereas in the "without 2nd success" model, the success of the 2nd attempt—unobservable when predicting the higher rival's 3rd attempt weight—is excluded.

The prediction for the 1st attempt yields an RMSE of 23.837 and an R^2 of 0.813, indicating that accurately predicting the 1st attempt remains challenging. In contrast, the predictions for the 2nd and 3rd attempts achieve an R^2 exceeding 0.99 across all models, demonstrating that even without incorporating the outcome of the preceding attempt, which is unobservable when predicting the higher rival's attempt weight, high predictive accuracy can still be maintained. Comparing the full models with the "without" models for both the 2nd and 3rd attempts, the full models exhibit slightly lower RMSEs (4.214 vs. 4.481 for the 2nd attempt; 3.450 vs. 4.191 for the 3rd attempt), indicating marginally better predictive accuracy. This suggests that the outcome of an attempt reflects the lifter's condition on the day of the competition, influencing weight selection, while lower-ranked rivals are unable to observe this condition. These findings support our assumption that the pressure variable—derived from predictions of the higher rival's attempt weight—is independent of unobserved factors such as the lifter's condition and can be considered exogenous.

To address the prediction error problem of using predicted values as explanatory variables, we implement a bootstrap procedure when incorporating the predicted attempt weight of lifter i's higher-ranked rival—unobservable to lifter i at the k-th attempt stage—into our regression framework. Since this predicted value, denoted by $\hat{Z}_{it}^{k}$, is derived from a separate estimation and contains prediction error, standard errors tend to be downward biased due to the smoothing effect of prediction. To correct for this, we apply a bootstrap approach that resamples the original data at the federation level, re-estimates the prediction model for $\hat{Z}_{it}^{k}$ in each bootstrap iteration, and then regresses the lifter's own attempt weight or success probability on the re-estimated $\hat{Z}_{it}^{k}$. This procedure ensures that the uncertainty in $\hat{Z}_{it}^{k}$ is incorporated into the standard error estimates by reflecting its sampling variability. Consequently, the bootstrap-corrected standard errors provide more robust inference on the effect of competitive pressure from higher-ranked rivals on weight selection and performance outcomes.

Compared to Table 5, which uses predicted higher rivals' attempt weights, Table 12 incorporates a bootstrap procedure to account for uncertainty in predicted higher rival attempt weights. This leads to slightly larger standard errors but consistent point estimates and signs. Notably, the male coefficient in the second attempt shifts from –1.279 to –1.477, and pressure from higher-ranked

Table 12: Regression of the Difference between the Second and Third Attempt Weight Compared to the Current Best on Pressure with Bootstrap

	(1)	(2)
Dependent Variable	W_{it}^2-(best)	W_{it}^3-(best)
Male	-1.477	3.210
	(0.384)	(0.529)
Body weight	0.274	0.355
	(0.014)	(0.033)
Num experience	0.229	0.255
	(0.052)	(0.098)
1(first participation)	32.849	34.061
	(0.989)	(0.984)
Pressure, lower rival, 2nd	0.111	
	(0.007)	
Pressure, higher rival, 2nd	0.440	
	(0.009)	
Pressure, lower rival, 3rd		0.068
		(0.007)
Pressure, higher rival, 3rd		0.407
		(0.010)
Control	X	X
Num.Obs.	246521	246521
R2	0.536	0.356
R2 Adj.	0.534	0.353

Notes: We control for gender, body weight, equipment category, age class, division, weight class, federation, and indicators for tie in declared weights and mismatch between lifting order and interim ranking. W_{it}^2 and W_{it}^3 are lifter i's attempt weights in the second and third attempts in competition t. Pressure from a lower rival at the 2nd attempt is calculated as (lower rival 2nd attempt) - (his 1st outcome), and pressure from a lower rival at the 3rd attempt is (lower rival 3rd attempt) - (his 2nd outcome). For higher rivals, predicted attempt weights are obtained as the mean from the bootstrap procedure, while standard errors are computed as the standard deviation of the bootstrap estimates, ensuring that the uncertainty in the prediction process is fully reflected in the inference.

rivals in the second attempt is stable, reinforcing the robustness of competitive pressure effects. Similarly, the effect of pressure from higher-ranked rivals in the third attempt remains stable (0.407 vs. 0.409 in Table 5). The stability of estimates confirms the validity of the benchmark results even when accounting for prediction uncertainty.

8 Conclusion

Using data from bench press competitions, our study highlights the impact of competitive pressure on lifters' attempt selections and success probabilities. Pressure from both lower- and higher-ranked rivals in the second attempt encourages more aggressive weight selections. In the third attempt, lifters continue to take risks under pressure from both directions, with higher-ranked rivals in particular inducing significant upward adjustments in attempt weights.

Heterogeneity analysis reveals that male lifters, experienced competitors, and those with repeated rivalry encounters respond more strongly to pressure. Male lifters take greater risks, while female and less experienced lifters remain more conservative. Familiarity with rivals amplifies responsiveness to competition. While success probabilities tend to decline under upward pressure for all lifters, the effect is notably stronger among women, underscoring the psychological difficulty of overtaking stronger competitors.

Counterfactual simulations show that without competitive pressure, lifters tend to adopt more conservative attempts. However, the effects on performance are highly heterogeneous: while some lifters benefit from the absence of pressure, some lifters experience lower success rates and reduced expected outcomes. These results highlight that external competition plays a dual role—motivating some lifters to perform better while destabilizing others—underscoring the importance of individual sensitivity in shaping performance under pressure.

Future research could explore structural estimation of decision-making across attempts. Lifters strategically allocate their stamina, a key aspect in SBD (Squat-Benchpress-Deadlift) competitions. Modeling this sequential structure—where lifters choose attempt weights, treat each lift as a lottery, and adjust under stamina constraints—could offer deeper insights into risk-taking and performance optimization.

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A Online Appendix (Not for publication)

A.1 Comprehensive Attempt Stage Model

In this section, we present an attempt stage model that simultaneously considers the influence of both the lower and higher rivals on the lifter's weight declaration. By accounting for both sources of competitive pressure simultaneously, this model provides a more complete representation of how lifters adjust their declared weights in response to the surrounding competition. However, the added complexity makes the model less intuitive to interpret, as the interactions between the two rivals' effects become more intricate.

We maintain the notation used in Section 3, let w_L denote the lower rival's actual attempt weight which is observable to lifter i during the attempt stage. Also, let w_H denote the higher rival's expected attempt weight under lifter i's rational expectations. Although this is not observable to lifter i's attempt stage, we treat this as highly predictable information to lifter i. Additionally, let y_L, y_H, and y_i represent the best outcome weights from earlier attempts within the competition for the lower rival, the higher rival, and lifter i, respectively, which are known in lifter i's current attempt stage. The (strict) inequality conditions $y_L < y_i < y_H$, determined by rank order, and $y_L < w_L$, $y_i < w_i$, and $y_H < w_H$, meaning that the outcome weight must not exceed the corresponding attempt weight, must hold. Although we can assume that $w_L < w_H$, meaning that the lower rival does not attempt to overtake two higher-ranked rivals as inferred from our data, must hold, we keep generality and allow $w_L > w_H$. These conditions determine the joint probability of the outcome tuple as shown in Table 13.

Table 13: Joint probability of outcome tuple

Pressure	i	L	H	Outcome	i's rank	Probability
$w_i < \min\{w_L, w_H\}$	S	S	S	$w_i < \min\{w_L, w_H\}$	$-$	$q(w)q(w_L)q(w_H)$
$w_i < \min\{w_L, w_H\}$	S	S	F	$w_i < \min\{w_L, y_H\}$	$-$	$q(w)q(w_L)(1-q(w_H))P(w_i < y_H)$
$w_i < \min\{w_L, w_H\}$	S	S	F	$y_H < w_i < w_L$	K	$q(w)q(w_L)(1-q(w_H))P(w_i > y_H)$
$w_i < \min\{w_L, w_H\}$	S	F	S	$y_L(< y_i) < w_i < w_H$	K	$q(w)(1-q(w_L))q(w_H)$
$w_i < \min\{w_L, w_H\}$	S	F	F	$y_L(< y_i) < w_i < y_H$	K	$q(w)(1-q(w_L))(1-q(w_H))P(w_i < y_H)$
$w_i < \min\{w_L, w_H\}$	S	F	F	$y_L < y_H < w_i$	$+$	$q(w)(1-q(w_L))(1-q(w_H))P(w_i > y_H)$
$w_i < \min\{w_L, w_H\}$	F	S	Any	$y_i < \min\{w_L, y_H\}$	$-$	$(1-q(w))q(w_L)$
$w_i < \min\{w_L, w_H\}$	F	F	Any	$y_L < y_i < y_H$	K	$(1-q(w))(1-q(w_L))$
$w_L < w_i < w_H$	S	S	S	$w_L < w_i < w_H$	K	$q(w)q(w_L)q(w_H)$
$w_L < w_i < w_H$	S	S	F	$w_L < w_i < y_H(< w_H)$	K	$q(w)q(w_L)(1-q(w_H))P(w_i < y_H)$
$w_L < w_i < w_H$	S	S	F	$\max\{w_L, y_H\} < w_i$	$+$	$q(w)q(w_L)(1-q(w_H))P(w_i > y_H)$
$w_L < w_i < w_H$	S	F	S	$y_L(< w_L) < w_i < w_H$	K	$q(w)(1-q(w_L))q(w_H)$
$w_L < w_i < w_H$	S	F	F	$y_L < w_i < y_H(< w_H)$	K	$q(w)(1-q(w_L))(1-q(w_H))P(w_i < y_H)$
$w_L < w_i < w_H$	S	F	F	$y_L < y_H < w_i$	$+$	$q(w)(1-q(w_L))(1-q(w_H))P(w_i > y_H)$
$w_L < w_i < w_H$	F	S	S	$y_i < w_L < w_H$	$-$	$(1-q(w))q(w_L)q(w_H)P(w_L > y_i)$
$w_L < w_i < w_H$	F	S	S	$w_L < y_i < w_H$	K	$(1-q(w))q(w_L)q(w_H)P(w_L < y_i)$
$w_L < w_i < w_H$	F	S	F	$w_L < y_i < y_H$	K	$(1-q(w))q(w_L)(1-q(w_H))P(w_L < y_i)$
$w_L < w_i < w_H$	F	S	F	$y_i < \min\{w_L, y_H\}$	$-$	$(1-q(w))q(w_L)(1-q(w_H))P(w_L > y_i)$
$w_L < w_i < w_H$	F	F	S	$y_L < y_i < w_H$	K	$(1-q(w))(1-q(w_L))q(w_H)$
$w_L < w_i < w_H$	F	F	F	$y_L < y_i < y_H$	K	$(1-q(w))(1-q(w_L))(1-q(w_H))$
$\max\{w_L, w_H\} < w_i$	S	Any	Any	$\max\{w_L, w_H\} < w_i$	$+$	$q(w)$
$\max\{w_L, w_H\} < w_i$	F	S	Any	$w_L < y_i < \min\{y_H, w_H\}$	K	$(1-q(w))q(w_L)P(w_L < y_i)$
$\max\{w_L, w_H\} < w_i$	F	S	Any	$y_i < \min\{w_L, y_H\}$	$-$	$(1-q(w))q(w_L)P(w_L > y_i)$
$\max\{w_L, w_H\} < w_i$	F	F	Any	$y_L < y_i < \min\{y_H, w_H\}$	K	$(1-q(w))(1-q(w_L))$

Notes: F = failed, S = success, K = keep. We ignore the equality case like $w_L = y_i$ in the probability because the body weight information works as a tie-breaker for the case.

Given the values of w_L, w_H, y_L, y_H, and y_i with the rank-dependent value function in Section 3, the expected evaluation of the lottery $(w_i, q(w_i))$ for lifter i with reference point r_i is

$$
\begin{aligned}
EU_i &= v(x_i - r_i)q(w_i) \\
&= \begin{cases}
\Big(q(w_i)q(w_L)q(w_H) + q(w_i)q(w_L)(1-q(w_H))P(w_i < y_H) + (1-q(w_i))q(w_L)\Big)[-\lambda] & \text{if } w_i < w_L, w_H \\
+\Big(q(w_i)(1-q(w_L))(1-q(w_H))P(w_i > y_H)\Big)[1] & \\
\Big((1-q(w_i))q(w_L)q(w_H)P(w_L > y_i) + (1-q(w_i))q(w_L)(1-q(w_H))P(w_L > y_i)\Big)[-\lambda] & \text{if } w_L < w_i < w_H \\
+\Big(q(w_i)q(w_L)(1-q(w_H))P(w_i > y_H) + q(w_i)(1-q(w_L))(1-q(w_H))P(w_i > y_H)\Big)[1] & \\
\Big((1-q(w_i))q(w_L)P(w_L > y_i)\Big)[-\lambda] + q(w_i)[1] & \text{if } w_L, w_H < w_i
\end{cases} \\
&= \begin{cases}
\Big(q(w_i)q(w_L)q(w_H) + q(w_i)q(w_L)(1-q(w_H))P(w_i < y_H) + (1-q(w_i))q(w_L)\Big)[-\lambda] & \text{if } w_i < w_L, w_H \\
+\Big(q(w_i)(1-q(w_L))(1-q(w_H))P(w_i > y_H)\Big)[1] & \\
\Big((1-q(w_i))q(w_L)P(w_L > y_i)\Big)[-\lambda] + \Big(q(w_i)(1-q(w_H))P(w_i > y_H)\Big)[1] & \text{if } w_L < w_i < w_H \\
\Big((1-q(w_i))q(w_L)P(w_L > y_i)\Big)[-\lambda] + q(w_i)[1] & \text{if } w_L, w_H < w_i
\end{cases}
\end{aligned} \tag{3}
$$

Although the representation of the expected evaluation of the lottery in Equation (3) may appear complex, in particular, when $w_L < w_i < w_H$, it reveals that there are discontinuities at w_L and w_H. Additionally, it is crucial to note that $P(w_i > y_H)$ (that is, chance of the higher rival's being turned around by the lifter) and $P(w_L > y_i)$ (that is, chance of the lower rival's turning around the lifter) are key factors that capture the pressure exerted by lower and higher rivals, respectively.

Even without further specification, Equation (3) offers theoretical predictions regarding the optimal choice of attempt weight w_i for each domain of w_i. First, if lifter i aims to choose w_i such that $\max\{w_L, w_H\} < w_i$, the optimal choice for w_i is $w_H + \kappa$, where κ is the minimum weight increment as specified by the competition rules, given that $q(w_i)$ is a decreasing function of w_i. Second, if lifter i chooses w_i such that $w_i < \min\{w_L, w_H\}$, the optimal choice is the w_i that maximizes $q(w_i)P(w_i > y_H)$, which leads to $w_i = y_H + \kappa$. Third, if lifter i selects w_i such that $w_L < w_i < w_H$, the optimal choice is w_i that maximizes $q(w_i)(1 - q(w_H))P(w_i > y_H)$, which also results in $w_i = y_H + \kappa$. Further analysis to precisely determine the analytical optimal attempt weight w_i across all domains of attempt weights would require additional specifications for $q(\cdot), q(w_H), q(w_L), \lambda$, and other parameters, which increases the complexity of the modeling, identification, and estimation processes, and is beyond the scope of this study and our data.