“Milk Crate Challenge”: Statistical Findings Behind the Social Media Phenomenon

Kris Caballero*

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Abstract

This paper analyzes the social media phenomenon that occurred in 2021 regarding odds of completion and its physical health risks associated, showing this challenge being a skill-based task than luck.

Introduction

Information acquired for this research involve online sources—YouTube—in making the calculations necessary. For this piece, a sample space of 100 attempts, or trials, have been considered. Sources tallied showed the best angle of crate structure for peak height quantity, their participant(s), and full recording of their attempt.

Tallied data fall upon these properties: the participant's gender, footwear, and their success, or fail, in attempting this challenge. Stacks shown have been counted by hand determining peak height, denoted as n, summing its structural build. In addition, these stacks are labeled by column vertically from left to right—i.e. peak height $n = 7$ defines as “7th column,” and its succeeding column becomes the 8th, etc. Another data added is delta height, denoted as ΔdH, tallied for failures: a change in column(s) the participant reached but failed. One more variable noted is surface where crate stacks were built atop of.

Goal of this challenge is to walk, run, or hop, through the stack, arranged in a stair-like pyramid, without falling. Rule is climbing through the crates without touching them; however, enforcement of this rule has been inconsistent, allowing the participant to continue anyway. Such enforcement of this rule has not affected the data entered in our sample space, only counting a participant's success or fail.

Mathematics describing our data entered and researched will be presented in the following sections.

*Email: kris@kcuniversal.net

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Mathematical Model

Overall Success Rate

Success Rate S of the crate challenge is a probability P proportional to our sample size 100. Thus, letting $P_{success}$ be the probability of total successes, we have:

$$P_S = \frac{S}{100} \tag{1}$$

Presented are bulletpoints on data entry set up for our findings:

- $S \in \{0, 1\}$: Binary result of the challenge attempted, where $S = 1$ indicates success.
- $H_{peak} \in \mathbb{Z}^+$: The crate's peak height defined H at its highest (middle column).
- $dH \in \mathbb{Z}$: Delta Height, dH, defined by $H_{i+1} - H_i$ for any step on the stack i. This was defined due to certain crate stacks built irregular (i.e. columns stacked two crates higher than its previous).
- μ: Coefficient of static friction provided by the ground surface.

Definitions

Definition 1 (Success Rate): Probability of Success as $P(S)$ for sample size N is:

$$P(S) = \frac{1}{N}\sum_{i=1}^{N} S_i \tag{2}$$

Where:

- $P(S)$ is the probability of success.
- N is sample size (100).
- i is the index starting at $i = 1$ per sample size.

Definition 2 (Devastations of Failure): Probability of Injury using the conditional:

$$P(I|F) = \frac{P(I \cap F)}{P(F)} \tag{3}$$

Where:

- $P(I|F)$ is probability of injury given the failure $P = 0$.
- $P(I \cap F)$ takes the probability of set I—injury—intersecting failures F.
- $P(F)$ is rate of failures.

Definition 3 (Attempts on Surface): Failure rate R_r are failed attempts on grass f_g proportional to its total n_g, thus:

$$R_g = \frac{f_g}{n_g} \tag{4}$$

as is similar to concrete where:

$$R_c = \frac{f_c}{n_c} \tag{5}$$

- R_g is failure rate attempted on grass.
- R_c is failure rate attempted on concrete.
- $f_{g,c}$ is failed attempts on grass/concrete.
- $n_{g,c}$ is total number of attempts done overall on grass/concrete.

Definition 4 (Footwear Successes on Grass): Successes determined by footwear is considered—many done on grass. Success rates of sneakers $S_{sn,g}$, socks $S_{so,g}$, and slippers $S_{sl,g}$, we have:

$$S_{sn,g} = \frac{s_{sn,g}}{n_{sn,g}} \tag{6}$$

Where:

- $S_{sn,g}$ is overall success rate for sneakers on grass.
- $s_{sn,g}$ is number of successful attempts done with sneakers on grass.
- $n_{sn,g}$ is total sample size of sneaker attempts on grass.

Propositions and Hypotheses

The Surface-Stability Inequality

Probability of completion is a function coefficient per static friction (μ) between crate base and the substrate. We define the Surface-Stability Inequality as:

$$P(S)_{grass} > P(S)_{concrete} \tag{7}$$

where empirical data suggests:

$$\lim_{H_{peak} \to 7} P(S)_{concrete} = 0 \tag{8}$$

[The Transition Risk] The probability of failure $P(F)$ is non-linearly distributed across Phase, reaching its maximum, per transition, from Peak to Descent ($dH < 0$).

The following is a sample table of data entered and recorded:

Results & Analysis

Success Rate (P_s)

Using our sample space of 100, and 21 total successes, we get:

$$P_s = \frac{21}{100} = 0.21 = 21\% \tag{9}$$

Injury Coefficient (I_q)

A total of 8 injuries occurred. Because injuries are derived from failed attempts, totaling to 79, we have:

$$P(I|F) = \frac{8}{79} = 0.1012 \approx 10.1\% \tag{10}$$

There were no witnessed injuries of participants having completed the challenge in relation.

Surface Index

Totaling 69 failed attempts done on grass, proportional to its total attempts of 88, and 9 via concrete, all whom have failed, we get:

$$R_g = \frac{69}{88} = 0.7840 \approx 78.4\% \tag{11}$$

$$R_c = \frac{9}{9} = 1 = 100\% \tag{12}$$

On the other hand, taking its successes on grass and concrete gives us:

$$R_g = \frac{19}{88} = 0.2159 \approx 21.6\% \tag{13}$$

$$R_c = \frac{0}{9} = 0 = 0\% \tag{14}$$

Therefore, with regard to static friction μ, this indicates:

$$\mu = P(S)_{grass} = 21.6\% > P(S)_{concrete} = 0\% \tag{15}$$

Footwear

We now find if footwear makes a difference attempting the challenge. Most popular footwear worn were sneakers (sn); irrespective of surface, this totals to 65 attempts, per our sample space. With grass (g) being the common surface, a total of 14 successful attempts have been done. In proportion, we get:

$$S_{sn,g} = \frac{14}{65} = 0.2153 \approx 22\% \tag{16}$$

Socks are second most popular footwear, and with 14 attempts total, only one (1) was successful, giving us:

Table 1: *Representative Sample of Data per Participant and Failure*

Phase	**Out.**	**Col.**	**Gen.**	**Footwear**	**Surface**	**Peak**	**Inj?**	dH_f	**Max** dH	**Technical Notes**
Descent: 5	F	5th	M	Slippers	Grass	8	No	dH = +1	dH = 2	dH = +2 at cols 6, 7; dH = -2 at col 8 (not reached)
Peak: 6	F	6th	M	Socks	Grass	7	No	dH = +1	dH = 2	dH = +1 at Peak 5
Completed	S	n/a	F	Sneakers	Grass	7	No	n/a	dH = 1	n/a
Descent: 8	F	8th	F	Barefoot	Grass	7	Yes	dH = -1	dH = 1	Participant dislocated right elbow
Descent: 8	F	8th	M	Sneakers	Concrete/Gravel	7	Yes	dH = -1	dH = 2	Participant suffered possible concussion

Note: dH values represent the height differential in crates relative to the previous step. NR = Not Reached.

$$S_{so,g} = \frac{1}{14} = 0.0714 \approx 7.1\% \tag{17}$$

Slippers were the third most popular footwear. Totaling to 13 attempts, and a success of 2, we get:

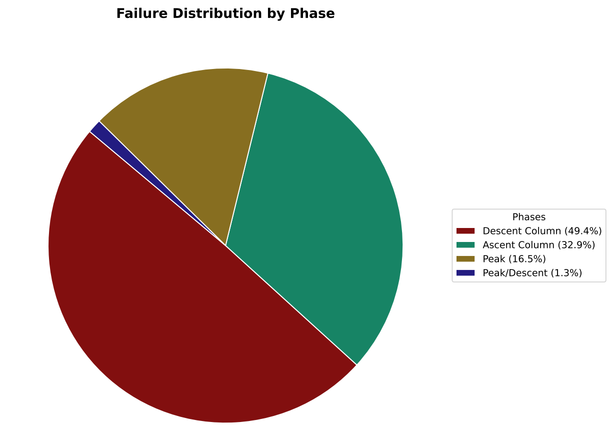
$$S_{sl,g} = \frac{2}{13} = 0.1538 \approx 15.4\% \tag{18}$$

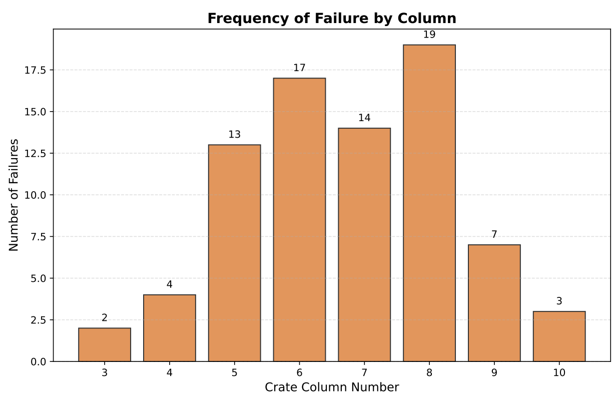
Irregular Crate Builds

Stacks of crates weren't all built equally with some having irregular, imperfect builds than the expected linear structure. Letting ΔdH be change in the build's height, equal to 1—$dH = 1$ for linear builds—some structures have ΔdH of 2, sometimes 3. These irregularities were apparent from our sample space and sources, likely built to present a tougher challenge. Reiterating, unofficial rules were enforced, as such stacks were built anyway.

Out of 100, there were 46 irregular builds with a $dH = 2$ or more. Exactly 13 irregular builds resulted in participants completing the challenge, giving us:

$$\frac{13}{46} = 0.2826 \approx 28.3\% \tag{19}$$





Discussion

Kinematics of the Descent

High-failure rates occurred in first steps from peak height to the descent. Biomechanically, climbing the ascent requires muscular strength against gravity ($dH = +1$). When reaching peak height, usually at $dH = 7$, participants transition from climbing to postural balance.

When peak height is at $dH = 7$, column 7, statistics above show eighth column resulted in the most failed phase. This is due to the participant's center of mass (CoM) when this transition occurs ($\Delta dH = +1 to - 1$).

Due to the crate's material manufacturing, exhibiting lack of frictional stability, this leads participants reliant on metatarsal heads and ball of their foot per lateral movement. A failure rate at nearly 50% is the result of participants' approaching this transition shifting from power-based climbing to fine-motor control, adding stress load, biomechanically.

Friction Coefficient and Surface Stability

Attempts on concrete yielded a 100% failure rate. Crates, typically made from high-density polyethylene (HDPE) on concrete substrates, provide negligent coefficient per static friction (μ). Compared to grass or soil, allowing some recessed "deformity" into the natural earth, no mechanical interlock exists on concrete. When weight of the participant shifts laterally, this leads to failure where frictional threshold is exceeded. For grass, its soil acts as a stabilizer dampening kinetic energy that causes stacks to collapse on harder surfaces.

Biomechanical Impact and Injury Severity

Falls from peak height, approximately 2.1 meters, result in high-velocity impacts. Injuries observed included orthopedic trauma—dislocated elbows, fractured ankles—and neurological risks—concussions. Surface material is the determining factor on an injury's severity. Though grass provides some impact attenuation (shock absorbency), concrete yields instantaneous transfer of kinetic energy to skeletal structure. Furthermore, lack of "break-fall" training among the general population led to improper landing techniques, such as extended limbs, increasing risk of fractures and joint dislocations.

Footwear Efficiencies

Footwear is another primary variable for proprioceptive result.

- **Sneakers (22% success):** Optimal traction is provided by rubber outsoles, plus its footbed stabilizes against the crate's surfaces.
- **Slippers 15.4% success):** Some surface resistance exists, though no ankle support when lateral shift occurs.
- **Socks 7.1% success):** A sock's fabric isn't an adequate enough grip on crates, despite having high tactile feedback.

Statistical Outliers

A couple successful anomalies were tallied, such as high-capacity heels and backward descent in barefoot. These attempts, where specialized balance or an above-average athletic conditioning, can probabilistically override the structure's mechanical instability, despite remaining statistically insignificant ($p < 0.05$).

Conclusion

Participants partake in challenges any which way, more-so with cash bets/prizes at the ready. As shown, plenty of factors play a role in winning this challenge. Statistically, while participants are nearly three (3) times likely to win on grass than concrete, these odds rest on lateral balance in part with the crate structure itself. Though footwear does play a factor, there were but a few, participants who defied odds succeeding where others didn't. In contrast, stability of the crate structure poses some risks. Because the average participant starks no contrast to being athletically conditioned, many aren't trained in fall-proof techniques that prevent impact, namely on head, spine, and elbows. This secured explanation of participants suffering from such injuries as a result.

As for crates, irregular builds were commonplace yet presented little challenge for the participants, roughly those below 25 years of age. Athletic agility proved their attempts—maintaining performance despite mechanical adversity of irregular structures. It is proof of skill by the participant(s) themselves, making a strong variable of success than uniformly built crate stacks. In conclusion, how the participant(s) approach challenges and/or situation, such as this, defies strategy and skill(s) solving such task(s) in real-time.

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