Do Skullcrushers Live up to their Name?

Introduction:

Weightlifting can be a dangerous undertaking. The strain on the body, the movement of heavy weight, and the desire to push oneself to achieve more create a situation fraught with danger. I myself know firsthand the consequences that come with these exercises. I have pulled, bruised, and cut myself lifting numerous times. One movement, however, has always scared me more than any other for its potential to end catastrophically. Skullcrushers, a triceps exercise, involves lifting a heavy weight directly over your head, and lowering it down until it is mere inches from the forehead (see picture). I have always wondered: do Skullcrushers live up to their name?

Research:

Before I began to crunch numbers I needed to collect some data that would be necessary for me to formulate and answer my question. First, I needed to measure the distance the weight
would travel as it fell onto the skull. To do this I measured the distance from an outstretched hand to the forehead, of three willing participants (including myself).

<table>
<thead>
<tr>
<th>Participant</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from hand to forehead (m)</td>
<td>0.385 m</td>
<td>0.402 m</td>
<td>0.426 m</td>
</tr>
</tbody>
</table>

I obtained and average distance of 0.404 m. Second, I needed to calculate the time that the collision lasted. Unfortunately, it would be disastrous and unethical to ask participants to drop weights on their foreheads so I could measure the time of the collision. Instead, I went in search of similar collisions that would yield a time similar to the collision in question. A scenario I found to be analogous is the interaction between a barbell and a hard floor when a weightlifter drops it after completing a deadlift. After searching online for videos\(^1\) containing this collision, I studied them frame by frame using Avidemux\(^\text{TM}\) and obtained an experimental collision time of 0.163 s.

<table>
<thead>
<tr>
<th>Video Studied</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured Collision time (s)</td>
<td>.16 s</td>
<td>.15 s</td>
<td>.16 s</td>
<td>.18 s</td>
</tr>
</tbody>
</table>

Lastly, I needed to determine how much force was actually required to fracture a skull. In my pursuit of this number I turned my search to online sources where I discovered that a force of

---

\(^1\) Links to the four videos are as follows:
1) [https://www.youtube.com/watch?v=fcbYHCQRCSA](https://www.youtube.com/watch?v=fcbYHCQRCSA)
2) [https://www.youtube.com/watch?v=e6jTYDglwZU](https://www.youtube.com/watch?v=e6jTYDglwZU)
3) [https://www.youtube.com/watch?v=AKZEk4NG1-o](https://www.youtube.com/watch?v=AKZEk4NG1-o)
4) [https://www.youtube.com/watch?v=a9jPo-9XKYQ](https://www.youtube.com/watch?v=a9jPo-9XKYQ)
4905 N is needed to fracture a skull. After collecting these three sets of data I was ready to formally write and solve my question.

**Question:**

A barbell is dropped from a height of 0.404 m onto a skull. The collision takes 0.163 s. What weight (in pounds) is required to cause a fracture if 4905 N of force are needed to fracture a skull?

**Solving the Question:**

The overarching physics principle involved in this problem is impulse. The magnitude of impulse (denoted \( J \)) is a measure of the change in momentum (see equation below).

\[
J = F_{avg} \Delta t
\]

\[
J = 4905N(0.163s) = 799 \text{ kg} \cdot \text{m/s}
\]

Using this equation I could find impulse by multiplying the time of the collision I determined experimentally with the force needed to fracture a skull. After solving for impulse I could plug it into the equation below to determine the mass needed to fracture a skull

\[
J = m\Delta v
\]

To solve this equation however I needed to determine the change in velocity of the weight as it interacts with the forehead. To do this I used the equation for constant acceleration (a

---

free body diagram of the weight as it falls is provided), to determine the velocity of the weight just before it strikes the forehead. The change in $y$ is the distance between the forehead and the wrist, and acceleration being $g$ (9.81 m/s). $v_0$ is 0 m/s because when the weight is motionless when in your hand, and begins its descent with no velocity. The final velocity determined by the constant acceleration equation would be used as the initial velocity in the impulse equation above with the final velocity being 0 m/s as the barbell comes to rest on the forehead.

\[
v_x^2 = v_0^2 + 2a(\Delta y)
\]

\[
v_x^2 = 0 + 2(-9.81 \text{m/s})(-.404)
\]

\[
v_x = 2.82 \text{ m/s}
\]

After obtaining the final velocity of the weight on its descent I plugged it and impulse into the equation above to obtain mass.

\[
J = m \Delta v
\]

\[
799 \text{kg m/s} = m(0 \text{m/s} + 2.82 \text{m/s})
\]

\[
m = 283 \text{kg}
\]

After obtaining the mass, weight can be calculated by multiplying mass by acceleration due to gravity, and then converting to pounds.

\[
W = mg
\]
\[ W = 283kg(9.81m/s^2) = 2780 \text{ N} \]

\[ 2780\text{N} \times \frac{1 \text{ lbs}}{4.448 \text{ N}} = 625 \text{ lbs} \]

**Results and Conclusion:**

After completing all necessary calculations, it was determined that a barbell weighing 625 lbs. would have to be dropped during a Skullcrusher for one to fracture their skull. 625 lbs. is an extraordinary amount of weight, and hundreds of pounds more than the record amount used in the exercise (I usually use no more than 60 lbs.), and therefore it can be determined that, while Skullcrushers can be hazardous to your health, they are not a real threat to cause a fracture.