Journal of Interdisciplinary Science Topics

Revealing the Magic of Skele-Gro

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17/03/2016

Abstract
This paper investigates the extent to which Skele-Gro increases the rate of normal bone growth by comparing the regrowth of Harry's arm bones to the rate of regeneration of bone in a fracture. The amount of energy provided by Skele-Gro is also determined. We find that the rate of bone growth is at least 90 times greater than that of a fracture repair and that the amount of energy that Skele-Gro supplies to do this is a minimum of 133,050 kcal. The lower estimate of Skele-Gro's power output is therefore 6443 W.

Introduction

In *Harry Potter and the Chamber of Secrets*, the 12-year-old Harry's tense Quidditch match against Slytherin is made all the more dangerous by Dobby's rogue bludger, which is intent on causing Harry enough injury that he is sent home. During the final seconds of the match when Harry is trying to catch the golden snitch, the bludger "smash[es] into his elbow" causing his arm to break [1].

The woefully inept Defence Against the Dark Arts teacher insists that he can fix Harry's arm, but instead removes all the bones from Harry's injured arm. The matron Madam Pomfrey then prescribes Harry a dose of Skele-Gro, used for growing bones that are missing [1].

This paper aims to find how the rate of normal bone growth compares to this accelerated growth, and how much additional energy Skele-Gro supplies in order to do this.

Finding the Time Bone Regrowth Began

Very seldom in the chapter is time referenced, which makes it difficult to determine the exact length of time Skele-Gro was working. Working backwards, the first time mentioned in the chapter is the time the Quidditch match begins - 11am [1]. It is difficult to ascertain how long the Quidditch match lasts in the chapter because as well as game-time, the Gryffindor team calls a time-out. Therefore estimations are made using what is seen in the films.

In the films, the scene begins with the game already in tow. Assuming that at this point a goal had just been scored (the score is 30-80 to Slytherin), and that there is an equal spacing of time between goals, we use the next goal 46 seconds later to find that the game has been underway for 8 minutes and 26 seconds at the beginning of the scene. Harry's bones are removed by Lockhart 48 seconds after the game ends, it having lasted a total 13 minutes and 2 seconds [2]. Therefore the bones in Harry's arm are removed at 11:13:50am.

In the books, when Harry is with Madam Pomfrey in the hospital wing, he "[holds] up the sad, limp remainder of what, half an hour before, had been a working arm" [1]. Therefore we can deduce that, assuming it takes 5 minutes before Harry takes the Skele-Gro (he puts on pyjamas and gets into bed), Skele-Gro begins working at roughly 11:50am. We also know that "Harry woke up on Sunday morning to find … his arm reboned" [1]. As he wakes up in time for breakfast, the maximum time Skele-Gro can be working is 24 hours.

Normal Bone Repair

The book describes "a strange and unpleasant sensation started at Harry's shoulder and spread all the way down to his fingertips. It felt as though his arm was being deflated" [1]. This indicates that he has lost 30 bones [3].

In reality, you are unlikely to ever find a situation where all the bones in your arm and hand suddenly disappear completely. Therefore, when looking at bone regrowth in a normal circumstance we would be considering the repair of a bone fracture rather than the growth of an entirely new bone.

The normal bone repair process can be separated into 3 steps: the early inflammatory stage, the repair stage and the remodelling stage. The inflammation process starts straight after the fracture and produces a haematoma, a blood clot within the tissue, within the fracture which forms the initial framework for producing new bone. This process typically lasts a few days. The repair stage starts when the haematoma is formed. Over time the clotted blood is replaced by a soft callus, made from fibrous tissue and cartilage, which forms around the fracture site. The soft callus is very weak and requires protection with a cast or other brace for the first 4-6 weeks of healing. Eventually, the soft callus will ossify into hard callus which in the case of a fracture is known as "woven bone"; this joins the fractured elements. In the remodelling phase, new bone continues to form returning the bone to its original shape, structure and strength. When loading forces are applied, the new bone will be laid down and resorbed depending on if it is required mechanically in that area. This process can take years, but usually enough strength will be returned in 3-6 months. [4][5]

As we can see, the time taken for Harry to regrow all the bones in his arm with Skele-Gro, let alone just a fracture, is at least 90 times quicker (1 day compared to 90) than is seen in the natural way of regenerating bone.

Nutritional Energy Demand

The regeneration of bone is heavily influenced by the amount of nutrition that the patient receives. A normal adult human requires approximately 2,500 kcal/day however a bedridden patient suffering injuries such as bone fractures may require as much as 6,000 kcal [6]. Scaling these values to those of the average 12-year-old boy (extrapolated from data from [7] and [8]), where 2,287 kcal/day are required under normal circumstances, gives 5,489 kcal/day required for an injured 12-year-old – a difference of over 3,000 kcal/day.

If Harry had not taken Skele-Gro and we model the regeneration of his bones to be similar to the repair of fractures, he may have been bedridden for up to a week, meaning he could require in excess of 21,000 kcal on top of those normally required. Assuming for the other 83 days of recovery he consumed the advised 15 kcal/pound [9] for an inactive individual (as in the story he is asleep while his bones regrow) and weighs the average weight of a 12-year old-boy (90 pounds [10]), this equates to 1,350 kcal/day or 112,050 kcal for the 83 days. Adding these values gives a total of 133,050 kcal required for bone regeneration over 90 days.

As Harry's recovery with Skele-Gro takes approximately 24 hours and there is no mention of him eating during recovery, we can say that Skele-Gro has the capacity to supply the additional 133,050 kcal (556.7 MJ) worth of energy required by the body to regenerate bones without causing any negative side effects.

From the energy and time taken to regenerate Harry's bones, we can then find a conservative estimate of the power output of Skele-Gro:

$$Power = \frac{Energy}{Time} \tag{1}$$

$$\frac{556.7\ MJ}{24\ \times\ 60\ \times\ 60\ s} = \ 6443\ W\ \ (4\ s.f.)$$

This is almost 2.5 times greater than the maximum power output of Usain Bolt during his 100 m world record [11], showing the impressive properties of Skele-Gro.

Conclusion

In conclusion, by modelling the rate of bone growth from a fracture, Skele-Gro increases the rate by a factor of at least 90. The energy expenditure that would be required when growing the bones was calculated to be at least 133,050 kcal. This gave a power output of 6443 W. These values are a conservative estimate and the energy expenditure is likely to be much greater; regrowth of a fracture, rather than 30 bones, was calculated over the maximum time Skele-Gro could have been working. Skele-Gro therefore must contain unexplained magical properties that allow it to hold such a vast amount of energy and indeed be able to apply it in a short period of time.

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