National Aeronautics and
Space Administration

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NASA

Reply to Attn of: CB

TO: CB/N. J. Sherlock

FROM: CB/W. Thornton

SUBJECT: Comment on Treadmill Bungee Changes

Background:

The primary purpose of these elements is to replace the force of body weight in weightlessness. This force is of the form:

Force = Constant (for the individual)
and may range from 100-200 + lbs. in this population.

Elastic bungees were the lightest, simplest means of doing this. Their force generated is of the form:

Force = $K_{constant}$ X, where X is the length of the bungee,

i.e., the force applied to the subject harness, and depends upon the type of bungee, K, and its length, X. Crudely adjustable straps were left on the harness to allow adjustment of X and resulting subject load. Since locomotion produces a variation in subject location and undesirable changes in force ($\Delta F \approx \Delta X$), this is minimized by making X as large as possible by 'folding' the bungees over pulleys. Such a system was never intended for the research uses to which it has been put.

Problems:

The bungees were deemed flammable and covered with a loose cloth which readily jams, especially in weightlessness and against the small diameter pulleys without bearings, reducing the effective length, X, and accentuating the very problem the pulley system was designed to overcome. Under some conditions the covering was stretched such that it became a fixed stay rather than a force generator. Another source of jamming was the bound overlap of multiple bungee cords required to achieve the desired compliance, K. Also these bindings were prone to fail which could result in sudden 'falls' or worse by the subject.

The proposed changes use a single cord with lashings at either end. This will end the problem of the lashing hanging and improves reliability, but does not address two other problems, i.e.,

1. Hang up and resulting erratic behavior of the bungee covered with loose cloth.

2. Unknown weight equivalent forces in use.

These problems were demonstrated in the course of examining the bungee performance.

Lab measurements:

Two sessions were spent in the Boeing lab with Mr. Warren England. Isolated bungee performance including failure load of the binding was reviewed. (Fig. 1) Next a new bungee with its cover was placed on a flight treadmill and load characteristics measured (Fig. 1).

A set of new bungees were then installed and measured for total force at the harness attach points. Table 1 lists total bungee forces at the harness and resulting vertical forces or Equivalent Body Weight (Eq. B.W.).

Table 1: Bungee Forces at Harness Attachment

	Front	Rear	Total
Min. (Max. strap length)	46	60	106 lbs.
Vertical Component (Eq. B.W.)	39.7	56.5	96.2 lbs.
Max (Min. strap length)	85	90	175 lbs.
Vertical Component (Eq. B.W.)	77.7	86.1	163.8 lbs.

Results:

Figure 1 shows the erratic behavior of the cloth covered bungee on the treadmill during two measurements versus its expected performance measured alone. So long as the loose cloth and small diameter pulleys are used this may be expected and will always result in unreliable and erratic operation. Such behavior is even worse with the existing (old) bungees.

Table 1 shows the equivalent body weight forces which range from 96 to 164 lbs. versus current office body weights of approximately 100 to 210 lbs. The old bungee forces were also inadequate.

Most serious of all the limitations is the impossibility of knowing what the Eq. B.W. in flight truly is. Even with perfect bungees and preflight individual calibration there will be enough variation in harness, height, position, etc., to make Eq. B.W. a poor guess.

Discussion:

This material is poorly flammable at best and either administrative or other means should be available to eliminate the loose cloth covering. Any bungee will be unsatis-factory with the present covering and small supporting pulley diameters.

Eq. B.W. forces to cover the range of crew weights should be available for many reasons. If the lower range of such forces are larger than desired by some crew members, extensions currently carried as part of the TM kit (reasons unknown) may be used to extend the harness and reduce the force.

Without knowledge of Eq. B.W. both operations and especially studies using this device become diversions or worse yet,misleading exercises from which damaging conclusion may be drawn, or to be more exact the machine remains a

toy. Life sciences was provided a crude scale for such measurements which was flown once--and confirmed the underloading e.g., ~ 107 versus 170 lbs. for one subject. More suitable designs were also provided and remain available.

Recommendations:

1. Eliminate the current cloth covering and replace the pulleys with properly designed units with larger radii, bearings, etc., to allow the unhindered movement essential to this bungee system's operation.

2. Adjust the bungee length and compliance to cover the current range of astronaut body weights.

3. If necessary use extensions in conjunction with item 2 to allow individuals to reduce minimum forces.

4. Obtain some form of scale to allow an approximation, even 5-10 percent of Eq. B.W.

   Note: W. England and other Boeing staff are thanked for their aid in this.

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