TVs - Tipping the Scale to Safety

A look into falling TV dynamics and incidents

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ABSTRACT

- **Objective** Review incidents related to falling television (TV) and the dynamics of a falling TV.
- **Design and Setting** Review falling TV incidents. Test a collection of TVs in the laboratory to determine fall/impact dynamics.
- **Setting** Laboratory testing.
- **Samples** Eighteen cathode ray tube (CRT) TVs and six flat screen (FS) TVs, sizes ranging from 19 inches to 32 inches (diagonal screen dimension). The CRT TV samples were collected at a recycling center or from U.S. Consumer Product Safety Commission (CPSC) staff and the flat screen TVs were purchased new from a local retailer.
- **Main Outcome Measures** Information on the dynamics of TVs falling from stands of various heights and impacting the floor.
- **Results** Thirty-eight drop tests were conducted with CRT and FS TVs. There were noticeable differences in the dynamics between the way a CRT and an FS TV falls toward the floor. The CRT TVs typically impacted the floor on the face of the TV; whereas, the impact points for FS TVs varied. The impact force was typically much greater for a CRT TV than an FS TV. On average, the CRT TVs impact force was between 1,900 and 12,703 pounds and the FS TVs were typically below 2,100 pounds of force. The average maximum force measured was 12,703 pounds for 32 inch CRT TVs dropped 36 inches.
- **Conclusions** Both CRT and FS TVs can cause serious injury on impact, and consumers, retailers, and manufacturers can play a part in preventing or reducing the chance of such an event occurring. Improving awareness of falling TV and furniture dangers and how to address these dangers are key components in preventing these accidents. for Affordable and easily-installed anchoring hardware is available to families to reduce significantly the likelihood of falling TVs and furniture. Additionally, providing an incentive to get rid of old CRT TVs when new FS TVs are purchased can accelerate the removal of CRT TVs in the home, thus preventing the old CRT TVs from being relocated to inappropriate platforms.

BACKGROUND

A TV, furniture, or appliance toppling over and crushing a child happens far too often. These incidents can be prevented. An estimated annual average of 38,000 emergency department-treated injuries (2011–2013) and 430 reported fatalities associated with TV, furniture, and appliance tip-overs occurred between 2000 and 2013, according to the CPSC. [1]

What fell? CPSC reported 41 percent of the estimated emergency department-treated injuries (2011-2013) involved televisions (or TVs and furniture). Some incidents resulted from the furniture the television was sitting on also falling onto the victim. Sixty-five percent (279) of the 430

PREVENTING TIP-OVERS

- ✓ Place the TV on sturdy furniture appropriate for the size of the TV or on a low-rise base.
- ✓ Secure the TV to the furniture with straps, brackets, or braces to prevent the TV from sliding.
- ✓ Mount flat-screen TVs to the wall or to furniture to prevent them from toppling over. Follow the manufacturer's instructions to ensure that you have a secure fit.
- ✓ If you have a large, heavy CRT TV, place the TV on a low, stable piece of furniture; or if you no longer use your CRT TV, consider recycling it.
- ✓ Secure top-heavy furniture to the wall with brackets, braces, or wall straps.
- ✓ Place electrical cords out of a child's reach, and teach kids not to play with them.
- ✓ Remove items that might tempt kids to climb, such as toys and remote controls, from the top of the TV and furniture.

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reported fatalities involved televisions falling (2000-2013).

With the number of TVs in U.S. homes, the possibility of a TV toppling onto a child is a real concern. There are an estimated 115.6 million TVs in homes in the United States (2013−2014), a 1.2 percent increase from 2012−2013, as reported by Nielsen's 2014 Advance National TV Household Universe Estimate. [2] As families purchase new FS TVs for the main viewing area, their older, cathode-ray tube (CRT) sets may be relocated to new areas of the home and placed on furniture not suitable for TVs, such as dressers or bookcases. CRT TVs are heavier towards the front of the TV because of the weight of the cathode-ray tube, making them prone to falling forward if tilted beyond their stability point. The current standard for TVs, Underwriters Laboratories (UL) 60065, requires that a TV not overturn when tilted 10° up from the horizontal plane. CRT TVs had a manufacturing limitation on the size of the tube that could be built, but FS TVs have exceeded the size limits of CRT TVs and appear to be getting bigger and bigger, potentially making them a danger if toppled over.

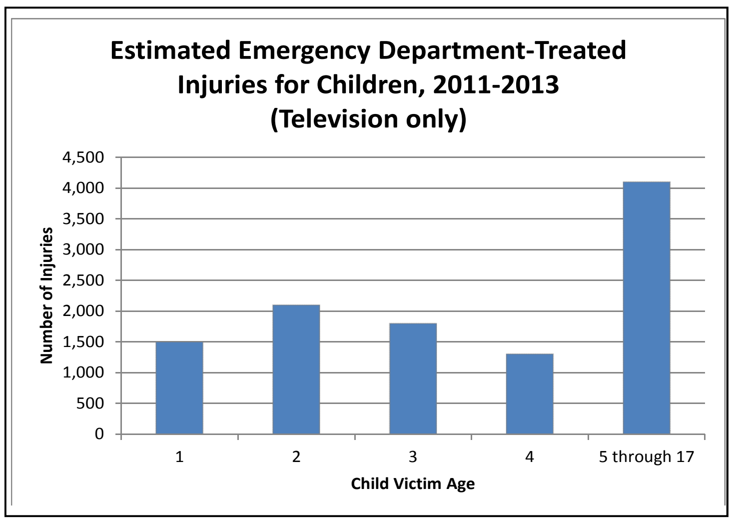
Falling TV injuries and fatalities are not only a concern in the United States. India [3] and Israel [4] had reported fatalities related to falling TVs. From 1997 to 2003, 116 children in Israel were injured by falling TVs. More than half of the children (54.3%) were 1 to 2 years old, and three-quarters of the TV-related injuries were head and neck injuries. [4] Similar injuries were occurring with falling TV incidents in India, where doctors reported the most frequent part of the body injured was the head (68%−72%).[3]

CPSC staff reviewed documented incidents recorded in CPSC databases to determine the scenarios around falling TV incidents. Subsequently, staff collected samples of TVs to evaluate the dynamics of TVs falling from various height platforms.

CPSC INCIDENT DATA

CPSC staff estimated that there were an annual average of 15,400 emergency department-treated injuries involving TVs (or TVs and furniture) between 2011 and 2013.[1] From 2000 to 2013, there were 279 reported fatalities related to falling TVs or TVs and furniture. An annual estimate of 9,800 (2011-2013) emergency department-treated TV injuries occurred to children younger than 9 years old or 11,000 injuries for children through age 17 (Graph 1). Two-year-olds and 3-year-olds account for most of the TV-related injuries, 2,100 and 1,800 injuries, respectively. An estimated 1,700 children were injured when a television and furniture both fell.

The circumstances that result in a TV toppling onto a child are sometimes unknown. Often, there are no adult witnesses to the event, and the adult is alerted to the incident by a loud crashing sound. Typically, a child playing alone pulls out the drawers on a dresser and uses the drawers as steps. This can cause furniture without anchoring hardware installed to tip forward. The child's weight contributes to the already front-heavy CRT TV, making the TV fall forward and toppling onto the child. These types of incidents have occurred when consumers place their TVs, unsecured, on top of furniture, such as chests or bureaus, not intended for TVs. An unsecured TV on unanchored furniture not intended to hold a TV is an accident waiting to happen.



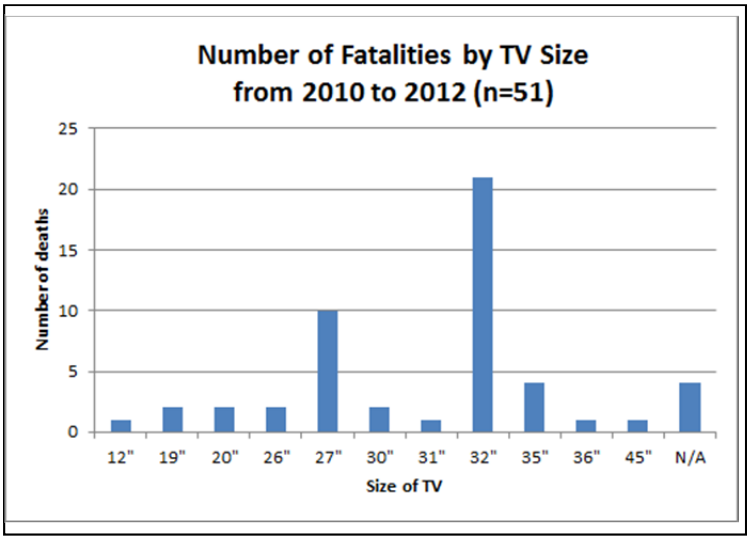
Graph 1. Annual Average of Estimated Emergency Department-Treated Television Injuries by Selected Child Victim Category, 2011-2013 [1]

In addition to fatalities, falling TVs can cause serious injuries. The type and extent of trauma sustained from a falling TV depends on the weight and size of the TV, the impact points on the victim, the length of time the victim is trapped under the TV, and the age and physical well-being of the victim. Of the annual average (2011-2013) estimated emergency department-treated injuries relating to falling TVs, most injuries to children affected the head (26 percent) and legs, feet, and toes (16 percent).[2]

From 2010 to 2012, CPSC staff investigated 51 recorded deaths directly resulting from a falling TV incident. Graph 2 shows the number of fatalities by TV size. The most common TV size and type in these incidents were 27-inch or 32-inch CRT TVs. The prevalence of 27-inch or 32-inch CRT TVs and their weights may be a contributing factor to the hazard in homes. In the 1990s, the average "main" TV set was 27 inches, and one in four households had a TV that was 30 inches or larger.[7] These TVs can weigh anywhere from 75 lbs. to 150 lbs., depending mainly on the weight of the picture tube.

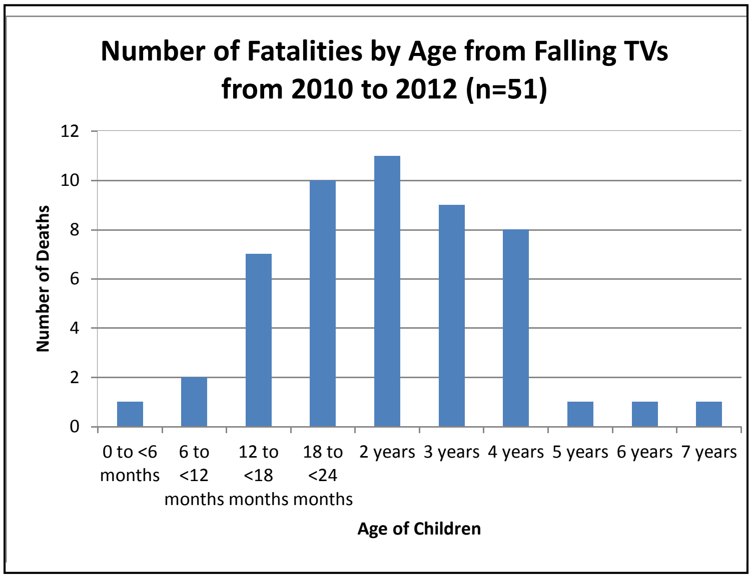
Of the 51 recorded deaths examined between 2010 and 2012, the greatest number of deaths, 45 (88%), resulted directly from a falling TV incident involving victims between the ages of 1 and 4 years. (Graph 3) The peak, around 2 years of age, coincides with the estimated emergency department-treated injuries for falling TV incidents.

It is not surprising that most of the reported victims were 2 years of age. At around 2 years old, children have increased control over basic gross- and fine-motor skills, which allows them to explore with newly found physical strength and coordination. Two-year olds are able to run, jump, climb, throw, push, and pull objects, which can potentially put children at risk around furniture and TVs that are not properly anchored.



Graph 2. CRT TV screen size and fatal incidents from 2010 to 2012

It is not only in recent years that falling TVs have been an issue of safety for small children. For more than a decade, CPSC staff has been investigating incidents where instability of TVs and TV stands has led to fatalities for small children, as shown in Table 1. These accidents likely could have been prevented if the TVs were anchored and placed on secured, stable, and appropriate furniture. Unfortunately, these fatal accidents have become more common since 2000.



Graph 3. TV fatalities from 2010 to 2012

Table 1. TV incidents from 2000 to 2009 [2]

Year	Number of fatalities from TVs	Year	Number of fatalities from TVs
2000	7	2006	23
2001	12	2007	25
2002	10	2008	29
2003	9	2009*	20
2004	11	2010*	22
2005	18	2011*	29

Asterisks (*) indicates ongoing data collection and compilation

Inci

dents that Could Have Been Prevented

Incident reports describe CRTs placed on inappropriate surfaces. This includes furniture that has multiple drawers and is not designed to support large CRT TVs. The furniture offers many opportunities for children to climb up the front of the furniture to reach the television. A TV on top of a dresser can shift the center of gravity (CG) of the items forward, making the items very unstable. The slightest amount of additional weight or force can cause the TV and furniture to topple forward. Large CRT TVs, placed on surfaces that are too small for the TVs, are also a concern. Large CRT TVs that do not sit well on small surfaces allow the potential for one of the feet on the TV to be unsupported, causing the TV to be unstable and topple over with the slightest movement.

In January 2010, a 2-year-old child was killed from the impact of a falling TV. A 27-inch CRT TV was situated in a bedroom on top of a four-drawer bureau that the child attempted to climb. This action caused the bureau and the TV to tip forward and topple onto the child. [5]

In April 2010, an 18-month-old child died when his mother laid him on the floor to change his diaper. His 6-year-old sibling leaned against a 31-inch CRT TV on a stand, causing the TV to topple onto the toddler. [6]

LABORATORY TESTING

The dynamics of a TV as it falls and impacts can be both simple and complex. A falling object is a simple physics concept; but including all of the factors, such as children climbing onto an open drawer and the size and shape of a TV, creates a more complex scenario. Accordingly, CPSC staff set out to record what happens when a TV topples off of a tipped horizontal surface from different heights and for different size CRT and FS TVs.

CPSC staff tested three typical sizes, 19 inches, 27 inches, and 32 inches, of the two categories of TVs: CRT and FS. The FS 27-inch TVs were actually 26 inches but will be grouped in the 27-inch category. The 19-inch, 27-inch, and 32-inch CRT TVs weighed between 40 lbs. and 60 lbs., 76 lbs. and 94 lbs., and 106 lbs. and 163 lbs., respectively. The 19-inch, 26-inch, and 32-inch FS TVs weighed 6.5 lbs., 10 lbs., and 18.75 lbs., respectively. A simulated piece of furniture/stand that could be adjusted to three different heights (36 inches, 48 inches, and 60 inches) was used as the supporting surface. Figure 1 shows the set-up for testing CRT and FS TVs.

Figure 1. CRT and FS TVs on the test stand

An automated piston was used to push (2 inches per second) on the rear of the stand to cause the stand to tilt forward. The bottom of the stand was hinged to prevent the stand from sliding and to allow an ideal tilt. (Figure 2) A chain stopper was attached to the stand to prevent the stand from completely falling forward and striking the fallen TV. The minimum angle of the stand before the TVs tipped over was about a 14° angle from horizontal.

Figure 2. Stand tilt and TV impact area

The TVs were placed on the center of the stand surface for each test. The stand surface was unfinished hardwood. A triaxial accelerometer on the TV was used to measure the TV departing the stand and impacting the floor. The accelerometer location was at the rear of the TVs to minimize the accelerometer being damaged during the fall. The impact surface was constructed of an indoor/outdoor style carpet, carpet padding, and plywood to simulate a flooring system in a home. (Figure3)

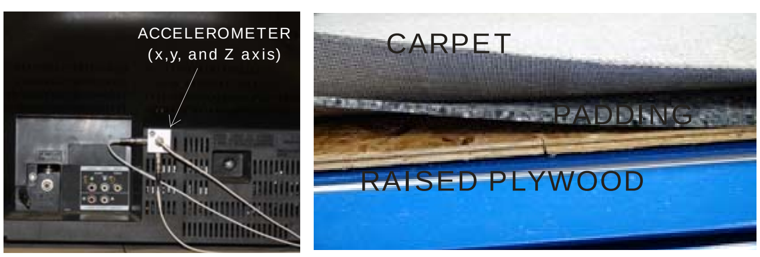


Figure 3. Accelerometer and flooring test set-up

RESULTS

Thirty-eight drop tests were conducted with CRT and FS TVs. A noticeable difference was observed in the way CRT TVs fell compared to FS TVs.

With the CRT, as the surface tilted, the TV typically began sliding forward. After the CRT slid off the surface, the CRT dropped in an almost parabolic motion, with the plane of the face of the TV leading the fall path. Figure 4 shows a sequence of images as a 27-inch CRT TV slid off the 48-inch-high surface. The TV landed squarely on the face of the TV and bounced a couple times. The time from when the TV began sliding to when the TV impacted the floor was slightly more than 0.5 second. In a scenario with a child at the front of the stand, the TV would strike the child, knocking the child to the ground, with the TV and furniture possibly landing on top of the child.

Although most of the CRT TV fall patterns were similar, there were drops that resulted in the CRT TV rotating enough to cause the first point of impact to be the front/top edge of the TV, with the TV coming to rest on its top. These drops only occurred with one of the 19-inch CRT TVs, which was lighter and had padded feet that prevented the TV from sliding.

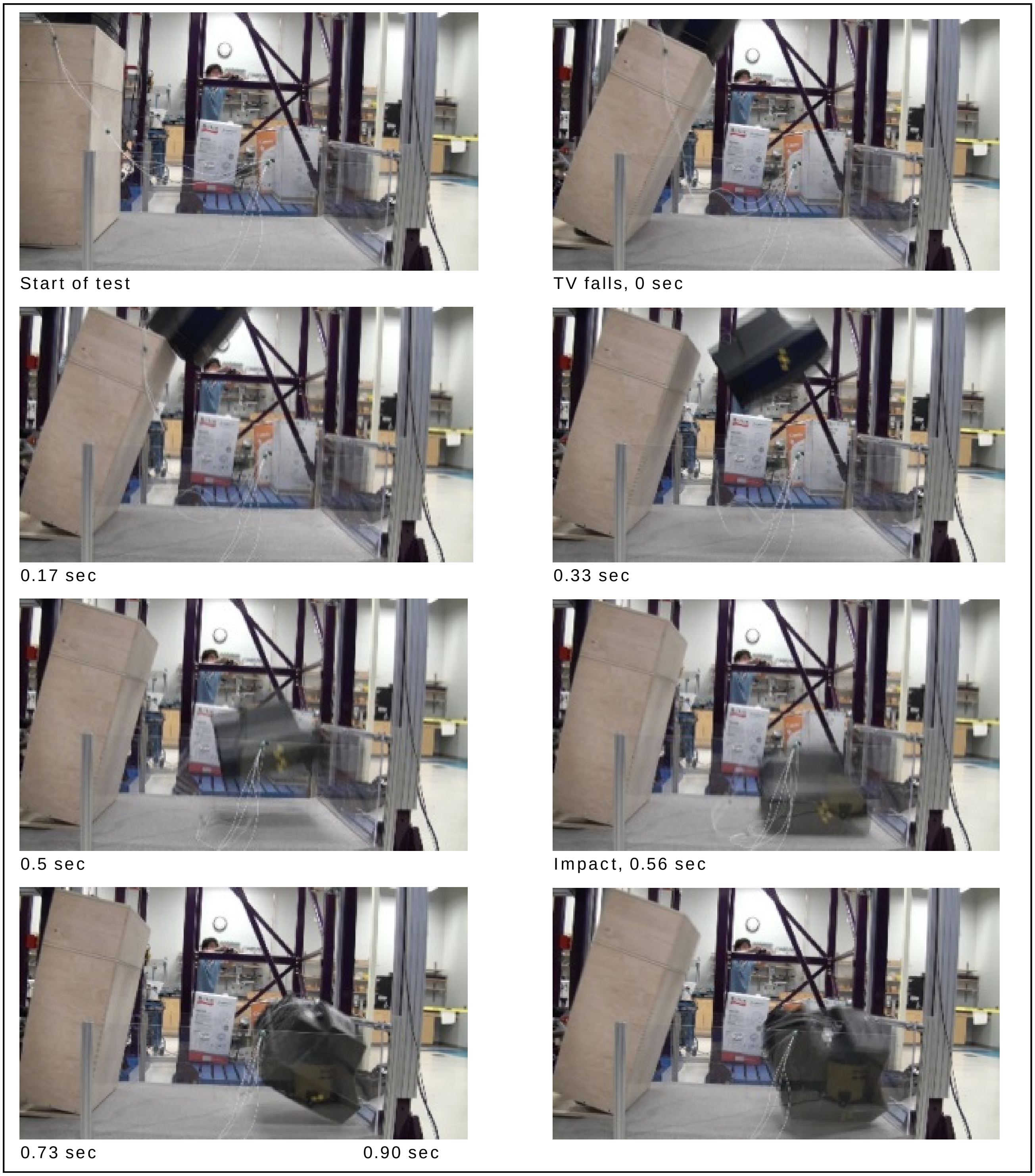


Figure 4. Sequence photos of a CRT 27 inch TV dropping from a 48 inch stand

For the FS TVs, as the surface began to tilt, the TV initially would lean backward slightly, but once the TV's center of gravity (CG) was forward enough, the TV would fall forward. The FS TVs did not slide along the surface but flipped over the edge of the stand toward the floor. The amount of rotation varied in each test, resulting in varying impact points on the FS TVs. Figure 5 shows a sequence of images as a 26-inch FS TV falls off the 48-inch high surface. The FS TV rotated 270° during the fall, causing the TV to land on its back.

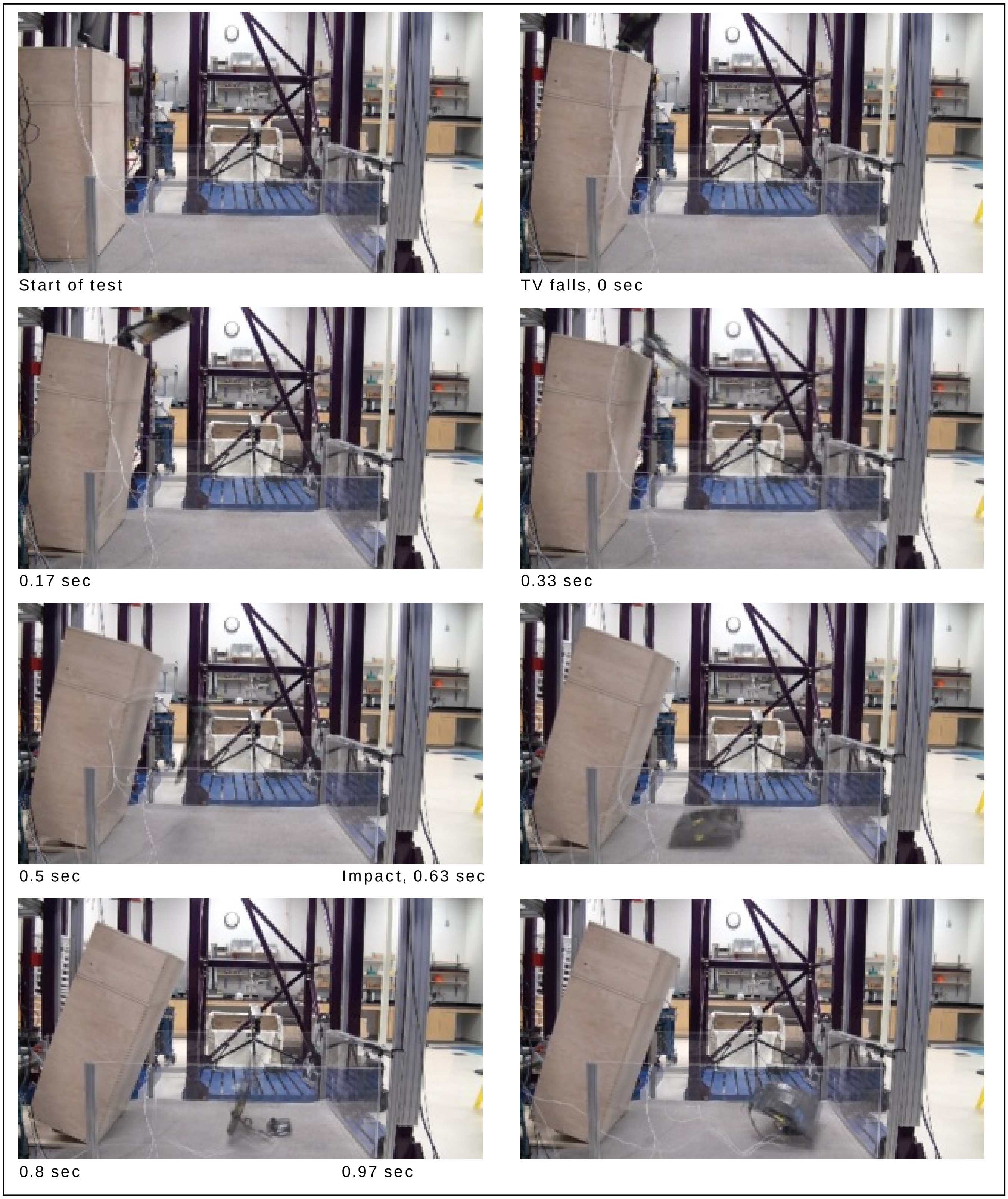


Figure 5. Sequence photos of a 26-inch FS TV dropping from a 48-inch stand

The fall patterns of the FS TVs were more random than the CRT TVs. The FS TVs' rotational angles varied, causing the size of the FS TVs' striking surfaces to also vary. In contrast, the CRT TVs' striking surface was usually about the size of the CRT face. The difference in the impact sound was also noticeable during the testing. The sound of an FS TV impacting the floor was very subdued compared to a CRT TV impacting the floor.

The accelerometer data also show the difference between CRT and FS TVs when they impact the floor. Typically, the FS TVs produced a shorter time duration peak pulse reflecting a quick event after the initial impact. The construction of the TV may also play a factor in the impact profile. For example, the FS TVs are very compact packages, resulting in less flexing and bending of the TVs. Figure 6 shows a short, quick peak pulse, which occurred when one of the FS TV's surfaces first impacts the floor.

The CRT TVs produced a much longer duration pulse. As mentioned previously, the impact typically occurred on the face of the CRT TV. Because the accelerometer was mounted on the rear of the TV, the instrumentation captures the long deceleration of the TV as the casing flexes and compresses during impact, causing a long event. Figure 7 shows the accelerometer output, which occurred when the 27-inch CRT TV impacted the floor.

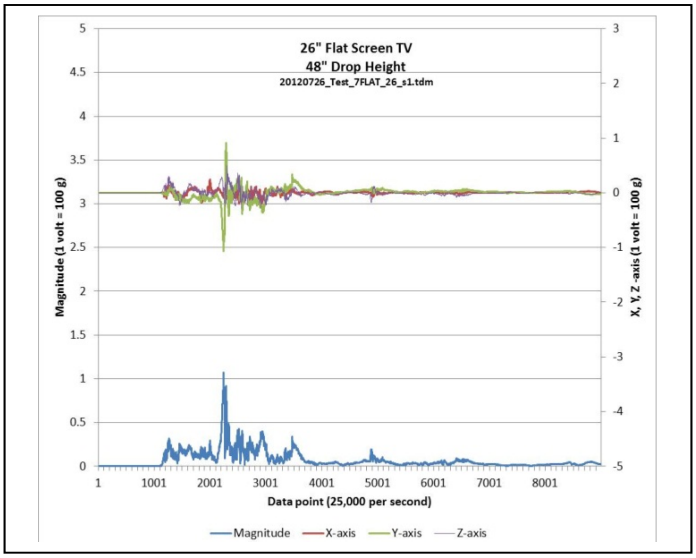


Figure 6. Accelerometer data for a 26-inch FS TV dropped from a 48-inch surface

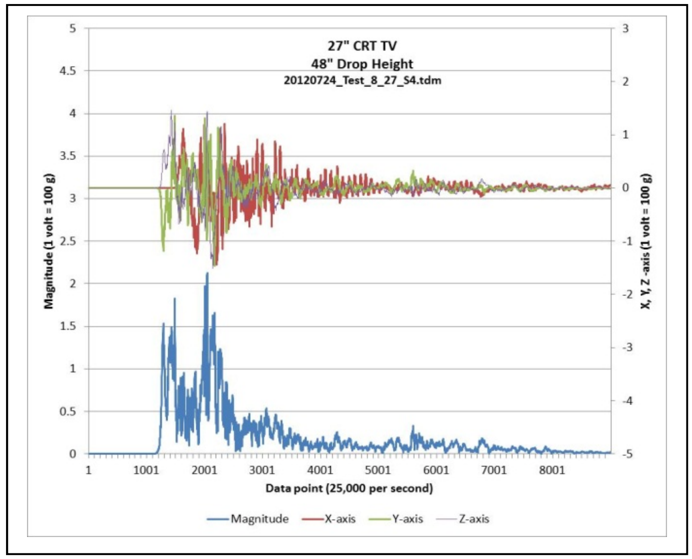


Figure 7. Accelerometer data for a 27-inch CRT TV dropped from a 48-inch surface

To record the direct impact energy on the front of the CRT TV, the accelerometer was cemented to the back of the tube on a 27-inch CRT TV. With the accelerometer mounted to the heaviest part of the TV, the impact data would more closely resemble the forces on the CRT when it impacted the floor. Figure 8 shows a 27-inch CRT TV impacting the floor with the accelerometer mounted to the CRT. The measured acceleration in each of the axes was slightly higher than when the accelerometer was mounted to the back of the tube, producing a greater magnitude pulse and a shorter pulse.

The measured acceleration was between 73 G and 240 G for the CRT and FS TVs. The short peak pulse widths for the FS TVs were clustered between 2 milliseconds and 9 milliseconds. The CRT TVs produced a wider range of pulse widths that generally ranged from 3.5 milliseconds to 27 milliseconds. An outlier for a CRT TV test occurred at 135 milliseconds. Figure 9 shows the FS and CRT TVs peak acceleration and pulse widths.

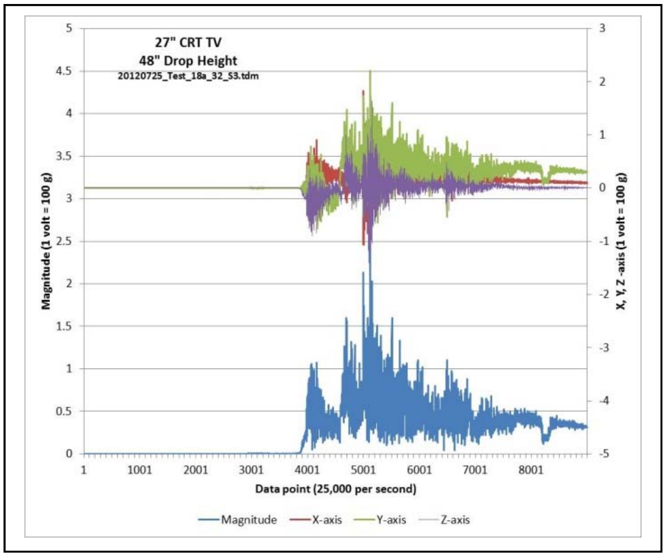


Figure 8. Accelerometer data for a 27-inch CRT TV dropped from a 48-inch surface with the accelerometer glued to the tube

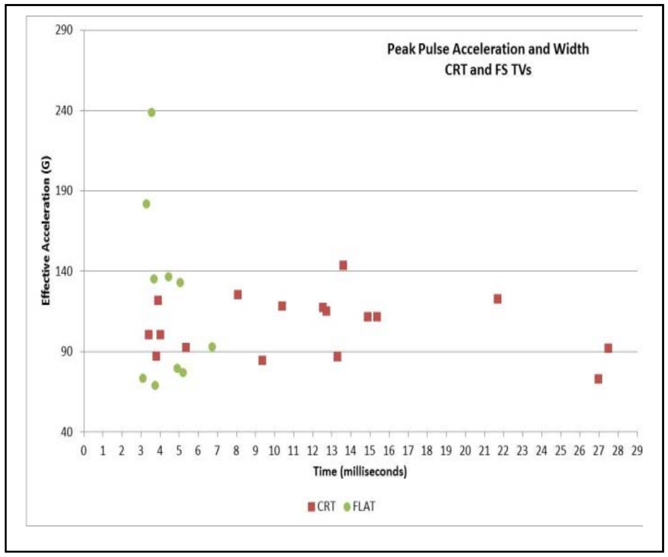


Figure 9. Peak pulse acceleration and width. Data point not shown, CRT test at 93 G and 135ms

One G is the force of Earth's gravity - it is this force that determines how much everything weighs. At 100 Gs, a TV experiences a force equal to a hundred times its weight. For instance, at a 100-G impact for a 50 lb. TV, there are 5,000 pounds of force. The acceleration at impact of the CRT TVs measured between 73 Gs and 143 Gs, which computes to between 2,920 pounds and 20,449 pounds of force. The FS TVs measured between 73 Gs and 240 Gs when impacting the floor, which computes to between 475 pounds and 4,505 pounds of force. The heaviest TVs did not necessarily impact the floor at higher acceleration levels because of the random striking surfaces and various rigidities of the housing constructions.

The average pounds of force for the same size CRT TVs were higher than those for FS TVs. Increasing the size and weight of the TV causes striking force to increase. In the tests, the CRT TVs exceeded 1,900 lbs. of force and the FS TVs were typically below 2,100 lbs. of force as shown in Figure 10. A toppling TV striking a child can result in an impact force of hundreds and thousands of pounds to the child resulting in severe trauma and possible death.

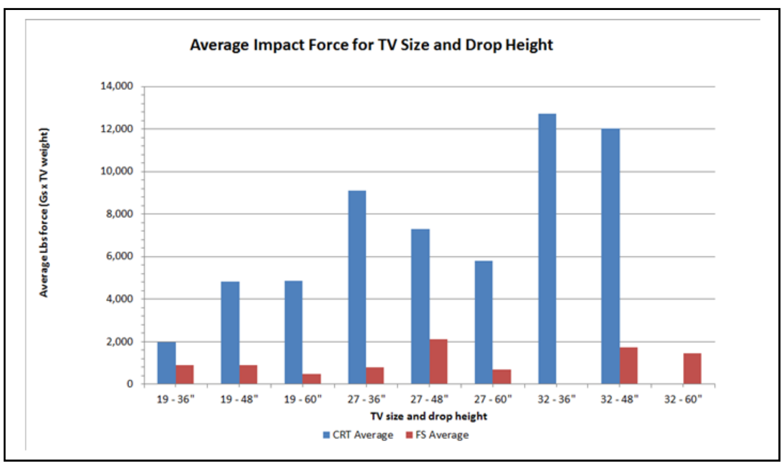


Figure 10. Average Impact Force (lbs.) for CRT and FS TVs.

DISCUSSION

Based on a review of incident data, consumers are placing CRT TVs on unstable or inappropriate furniture. Furniture, such as a dresser or bookcase, becomes even more unstable after consumers set their old CRT TVs on top of it. Unfortunately, any additional weight on the front of the furniture can easily cause the TV and the furniture to topple over. The size and weight of a TV makes its impact force lethal.

The dynamics of a CRT TV or FS TV as it falls may also be playing a role in the injuries. When a CRT TV falls, the striking surface typically is the full face of the TV, capturing anything within its path. A FS TV falls with rotation, making the striking surface random. As an FS TV falls, the striking surface may be the side of the screen, a portion of the front or back, or the stand, reducing the odds of a child being severely injured.

Also, FS TVs are much lighter than their comparable screen-size counterpart, older CRT TVs. This has made them possibly less dangerous when they fall. In either scenario, a falling CRT TV or FS TV is not desirable because both types of TVs have the potential to cause serious injury or death.

CONCLUSIONS

TVs toppling from furniture result in injuries and deaths among children. Incidents occur when families place TVs on surfaces not suitable for TVs, such as dressers, bookcases, and small tables.

Up to 12,700 lbs. of force strikes a child when a large, unanchored CRT TV topples off furniture. Less than 2,100 lbs. of force strikes a child when a flat screen TV falls. In either scenario, a toppling TV striking a child can result in an impact force that can result in severe trauma and possible death. Both CRT and FS TVs can result in serious injuries when falling, and everyone can play a part in preventing or reducing the chance of such an event. These accidents can be prevented by simply anchoring TVs and furniture.

CPSC staff recommends the following:

Consumers

- Do not place TVs on unstable surfaces.
- Use straps to secure TVs and furniture.
- Consider disposing of and recycling old CRT TVs.
- Place TVs on low surfaces.

Retailers and Manufacturers

- Train sales associates to inform consumers of the dangers of TV tip-over incidents and methods to prevent these incidents.
- Use in-store displays to remind shoppers of the danger.
- Provide free straps for consumers to secure both the TV and furniture.
- Provide incentives for the owners of CRT TVs to dispose of the TVs when they purchase new flat screen TVs.

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