Pediatric Hand Friction Burns from Treadmill Contact

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Abstract

Background Treadmills have become relatively common in American homes. This machine can be dangerous for children because they can sustain friction burns to the hands when the moving treadmill is touched. With aggressive wound care and physical therapy, most of these burns will heal without surgery. However, some patients will require reconstructive surgery to release contractures. We report our experience with a series of patients who suffered friction burns to the hand from contact with a moving treadmill. The purpose of this study is to further understand the incidence and outcomes of this type of injury. **Methods** A retrospective chart review of all patients referred between September 2002 and June 2005 to our hand surgery clinic for treadmill friction burns on the hand (s) was conducted. Pertinent data collected included sex, age, injury distribution, and surgeries performed. An analysis of data maintained by the Consumer Product Safety Commission was used to understand the incidence of exercise equipment-induced injuries.

Results Thirteen pediatric patients were evaluated for friction burns on the hand. Their total injuries included 24 fingers,

1 hand, and 1 forearm. Three patients (23%) required surgery for release of flexion contractures. All wounds of the remaining 10 patients healed, and with the implementation of hand therapy programs did not require subsequent surgery. **Conclusions** Treadmill friction burns to the hands of children can lead to limitations of the motion of the hand. Because this problem is completely preventable, parents and treadmill manufacturers are encouraged to be proactive in preventing these injuries. In addition, prompt initiation of wound care and hand therapy is integral to a favorable outcome.

Keywords Pediatric · Hand · Burn · Treadmill

Introduction

With the rise in recent decades of home fitness, various pieces of exercise equipment, including treadmills, can be found in many homes. As with any large piece of equipment, injuries to children are a distinct possibility. Most treadmills consist of a walking/running platform with a rubberized belt that is driven by a motor in the machine. Depending on the settings used on the treadmill, the belt can move at speeds greater than 8 ft/s. At these velocities, a rubberized belt can easily cause friction injuries when in contact with skin, especially that on the soft, noncallused hands of small children.

It is difficult to determine the true incidence of home treadmill injuries as well as trends regarding this incidence. A recent study by Abbas et al. [1] explored the Consumer Product Safety Commission's data on exercise equipment accidents in the home. In children aged 5 or less, there were 1,009 injuries from 1996 to 2000. More than half of these were on the upper extremities (56%), and of those, 90% were on the hands and fingers. Whereas contusions and

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abrasions constituted the bulk of these cases, this is still a large number of potentially significant injuries from exercise equipment.

In this study, we report on a group of children who have sustained a friction injury to their hands or wrists because of contact with a moving treadmill. These injuries are almost always preventable, and their care should be addressed with immediate wound care and hand therapy. The purpose of this study is to describe a cohort of patients who have sustained this type of injury, the specific injuries that can be expected when contacting a moving treadmill, and the outcomes of treatment, especially such as that related to time to referral. A secondary goal of this study is to gain some insight into the incidence of this type of injury.

Methods

This study received Institutional Review Board approval from the University of Washington, and complied with all regulations regarding the use of human subjects.

A retrospective chart review of all patients referred to our hand surgery clinic for hand burns was conducted. Between September 2002 and June 2005, 13 pediatric patients were referred to our hand surgery clinic for hand friction burns caused by treadmills. Pertinent information that was collected included age, sex, distribution of friction injury to the upper extremity, wound care methods employed, and surgeries performed (if necessary).

Injury Management

In general, the management of acute friction injuries is similar to that of other thermal injuries. If the wound is superficial or superficial partial thickness, bacitracin ointment (Pfizer, New York, NY, USA) is applied; and if it is deep partial thickness or full thickness, silver sulfadiazine cream (King Pharmaceuticals, Bristol, TN, USA) is utilized. Depth of burn can be initially somewhat difficult to assess because of the glabrous nature of the palmar skin; however, within approximately 7 days, the burn depth seems to become more apparent. Also, in the acute phase, upper extremity splinting is utilized. This is typically in the intrinsic-plus position, which is slight wrist extension, 90° flexion at the metacarpophalangeal joints, and total or near-total extension of the interphalangeal joints of the fingers. When the wounds are confined to the fingers, a hand-based or finger-based splint can be employed. In terms of monitoring wound healing, burns are typically given 3 weeks to heal. If, by the 3-week mark, deep partial thickness or full-thickness burns appear unlikely to heal by secondary intention without contracture, they are debrided and resurfaced with full-thickness skin grafts or

local flaps. It is not necessary to have closed wounds before initiation of therapy, and range of motion therapy often begun while wound care is ongoing.

Once the wounds have healed, the rehabilitation tactics are changed to emphasize scar management. The chief purpose of this is to prevent heavy scarring and joint contractures, both of which can be debilitating. The scar management program consists of continued splinting, scar massage, and application of silicone sheeting. Topical application of silicone tape has been shown to soften scars [10].

In an effort to better understand the incidence of exercise equipment accidents in the home, a query was performed using the National Electronic Injury Surveillance System [12]. The four-digit code for home exercise equipment (3277) and age limits of 1 month to 10 years were used. Yearly queries were performed on a 5-year interval from 2001 to 2005, and actual and extrapolated national incidences were obtained.

Results

This series is comprised of 13 children with hand, wrist, and forearm injuries due to treadmill friction burns. There were four girls and 9 boys in the group. The average age of the patients at the time of injury was 3.6 years (range 1–12 years). Mean time to presentation to the hand surgery clinic was 152 days (range 6–1,080 days). The mean follow-up was 18 months (range 2–36 months).

The specifics of each child's injuries can be found in the accompanying table (Table 1). Eight children had burns on the volar side of the hand with a total of 17 fingers injured. Five had injuries to the dorsal side of the hand with a total of 7 fingers, one forearm, and one hand injured in this group. In addition to cutaneous burns, one child in this group (dorsal injuries) had a right middle finger proximal phalanx fracture that was nondisplaced. This fracture was treated with splinting. Figures 1 and 2 demonstrate acute burns to the volar surface of the fingers.

Nine patients in this series were seen in our clinic acutely after injury. All of these patients had what were characterized as partial thickness or superficial burns, and all demonstrated noticeable progress in healing in the first 14 days after injury. For this reason, no acute excision and grafting was performed for these nine patients. All of the patients in this series were eventually managed with our wound/scar care plan as described above. Some children were not referred to this hand surgery clinic until wound healing was complete (four patients), therefore the acute phase of their management may have had differences in wound and scar management from that described previously.

Ten of thirteen patients in this series eventually had full healing of all wounds, and no limitation in range of motion in

Table 1 Patient data.

Age	Injury	Burn Depth	Management	Surgery
2	Volar right MF and RF	Unknown	Scar massage	Scar release, FTSG
2	Volar/ulnar right MF, RF	Partial thickness	Silvadene, splinting, scar massage	None
4	Volar right IF, MF	Superficial	Bacitracin, xeroform, splint, scar massage	None
12	Dorsoradial left MF	Superficial	Bacitracin	None
4	Volar radial right small finger	Superficial	Bacitracin	None
2	Dorsal right forearm, hand	Unknown	Splint, scar massage, silicone	None
2	Dorsoulnar right MF, RF, dorsoradial small finger	Superficial	Bacitracin, splint, scar massage	None
3	Volar left MF and RF	Partial thickness	Silvadene, splinting	None
1	Volar right IF, MF, RF, SM	Unknown	Silvadene, splinting, scar massage	Scar release, FTSG, flaps
7	Right volar ulnar MF, RF	Partial thickness	Silvadene, splinting	None
2	Right dorsal IF	Partial thickness	Silvadene, splinting	none
3	Right dorsal radial IF, MF, RF	Partial thickness	Silvadene, splinting	none
3	Right volar RF	Unknown	Unknown	scar release with Z-plasties

FTSG = Full-thickness skin graft, MF = middle finger, RF = ring finger, IF, index finger, SM = small finger

the digits, hand, or wrist. Three children (23% of the cohort) have required surgery to treat secondary deformities related to a treadmill injury. One patient was 2 years old at the time of injury, which was confined to the volar side of his right middle and ring fingers. Despite 7 months of aggressive scar management, he required surgery for severe flexion contractures proximal interphalangeal (PIP) joint of the right long and ring fingers (65 and 70°, respectively). These contractures were treated with incision of the volar scar on

Figure 1 Two-year-old child with friction burn to volar surface of small finger.

these digits followed by application of full-thickness skin grafts to the wounds. This child has been followed for 28 months since this operation, and he has made a satisfactory recovery without any limitation in range of motion or function (ring and long finger PIP extension 0°). Another child was 1 year old at the time of injury to her right volar index, middle, ring, and small fingers. Because of some misinformation given to the family about the timing of potential surgery, she was unfortunately not seen in the hand clinic until one and a half years after the injury. By this time, she had developed severe flexion contractures on the volar surfaces of the ring and small fingers (60° at both PIP joints), as well as a traumatic syndactyly between these two digits. At approximately 2 years after the injury, the patient underwent contracture releases of the ring and small fingers with Z-plasty closure and syndactyly release with full-thickness skin grafts. This child now has full range of motion at the ring and small finger PIP joints. The third child who required surgery had a similar presentation: she was not initially splinted, and she was not seen in the hand surgery clinic until 3 years after her injury. She was brought in for consultation about a flexion contracture on her right ring finger PIP joint. This contracture was approximately 25°. It was treated with scar lengthening using multiple Z-plasties. Since surgery, this patient has regained full range of motion of the ring finger PIP joint (0° extension). As per documentation received from these three children's prior treating

Figure 2 Three-year-old child with burns on left middle and ring fingers.

physicians, all three of these burns appeared deep, but no conclusive statement was made regarding depth of burn (full thickness, partial thickness, or superficial).

The other adverse outcome that has been noted at follow-up is hypertrophic scarring in the patient with burns to the dorsum of his right forearm and wrist (Fig. 3). These scars are not symptomatic, and are causing no limitation of function. They continue to be managed with scar massage and application of silicone sheeting.

The query of the Consumer Product Safety Commission's National Electronic Injury Surveillance System revealed fairly constant incidences of home exercise equipment injury from 2001 to 2005 [12]. The yearly incident number ranged from 410 (2004) to 463 (2003) with a mean of 433. Furthermore, the extrapolated national estimate was an average of 12,073 (range 11,247–12,785). Total reported injuries of all types from those years ranged from 347,000 to 360,000 (extrapolated national estimates 12.6–13.3 million). In looking more specifically at hand injuries from home exercise equipment, the query revealed that the reported number of injuries over this same time period ranged from 27 to 44 (mean 37). These numbers were too small to generate extrapolated national estimates. Whereas the national incidence of exercise equipment-induced injuries (and injuries overall) does not appear to be increasing, it unfortunately does not appear to be decreasing either.

Discussion

The purpose of this study was to describe one hand surgery group's experience with treadmill contact burn injuries, the outcomes thereof, and the general incidence of this type of injury. Upon first look at the data from this study, it might appear that treadmill burns to the hand in pediatric patients are not a severe or common problem. In reviewing the literature regarding this type of injury, most of the studies are small in scope [1–5, 8, 9]. However, data from the Consumer Product Safety Commission obtained by another group [1], and that obtained for this study, demonstrate that injuries to children caused by home exercise equipment remain a problem that does not appear to be abating. It is reasonable to conclude that pediatricians and hand surgery practitioners will continue to see these types of injuries for the foreseeable future.

The majority of the patients in our series have what can be considered good outcomes, mostly through conservative management. However, in looking more closely at the issue, one sees that this is potentially a significant problem. The experience from this study took less than 3 years to accumulate, and it is the experience of only one hand surgery group.

Three patients from our series (23%) required surgical intervention. The number of these types of burns and the percentage necessitating operation is similar in another series. Carman and Chang [5] published an often-cited series of 12 pediatric patients with treadmill burns to the hand. Half of the children in that series required surgery, one of whom underwent acute excision and grafting. Another five patients required surgery for contractures or delayed healing. Other studies seem to correspond to the Carman and Chang study in terms of scope and surgical

Figure 3 Hypertrophic scarring on the dorsum of the hand after treadmill-induced burn.

rate, with patients requiring surgery 21–50% of the time [3, 4, 8, 9]. In the current study, there were no patients that underwent acute excision and grafting, either because the burns had healed before arriving at our clinic, or because it was judged that they would heal with conservative measures. Others have seen acute burns that merited excision and grafting, all of which were full-thickness burns at the time of presentation [3–5, 8]. Marshall's study intentionally excluded full-thickness burns, and not surprisingly, there were no patients in that series that required acute or subacute excision and grafting [9]. Whereas ours is a small series and is not large enough to draw conclusions about the true incidence of this problem and the number of patients that will need surgical correction for post-injury problems, we do feel that the incidence and surgical rate of this series and others indicate a problem that deserves attention.

Whereas it is at times difficult to compare injuries from different mechanisms, a cursory analysis of other pediatric hand burn mechanisms can be revealing. Grob et al. [7] published a small series of children who sustained hand burns from contact with vacuum cleaners. This mechanism is similar to the treadmill injuries as it appears to be a burn primarily caused by friction generated by the hand contacting the rotating bar on the underside of the machine. Of seven patients analyzed, all but one sustained full-thickness burns, and four patients (57%) underwent acute excision and grafting. Contact with the glass screen of fireplaces is also a common way in which children can sustain burns to the hands. Naqui analyzed 35 children who sustained these types of contact burns and found that most were superficial, and only one patient required acute excision and grafting [11]. No patients in that series required secondary surgery for contractures. Similarly, Zettel et al. [13] also found that in 27 children who sustained contact burns from fireplaces, only 3 (11%) required acute excision and grafting. The outcomes in both of these studies were generally good. From these various reports, one might conclude that treadmill contact produces surgical rates that are higher than contact thermal burns, but are on par with other types of friction burns.

As with most traumatic injuries, prevention should be a prime concern. Parents and guardians of children should take all steps to prevent young children from being near these machines, and manufacturers can help by employing prominent warning labels as advocated by the Consumer Product Safety Commission [6].

It seems apparent that immediate initiation of hand therapy and wound care is essential to good outcomes, and can possibly avert surgery for these children. Hypertrophic scarring and contractures are usually evident within a relatively short period of time after injury, and hand therapists are able to employ aggressive therapy to ameliorate the effects of this post-injury problem. It is interesting to note that the adverse outcomes in this series (three patients

necessitating surgery, and one with exuberant hypertrophic scarring) were seen in patients who came to our clinic at more than 1 month after injury (30, 565, and 1,080 days in the patients who required surgery, 220 days in the patient with hypertrophic scarring). None of these four children underwent initial aggressive therapy and splinting. Two other groups have raised the issue of timing in terms of initiation of wound care and therapy. Maguina et al. [8] noted that 4 of 10 patients in their series were referred weeks or months after injury, and all 4 had deep burns that had not healed or had developed contractures. They do not say whether the delayed referral group fared worse overall. Marshall and Lourie [9] write of a 14-patient series in which 8 patients were referred in delayed fashion. All eight of these patients presented with contractures, four of whom warranted surgery (one family refused surgical intervention). While we cannot definitively say if earlier or more aggressive hand therapy would have prevented the severe contractures or hypertrophic scarring seen in our patients, or in those of other series who presented to the hand surgeons in a delayed manner, every patient deserves the opportunity to avoid functional limitation and subsequent surgery. One might reasonably conclude that at least a portion of patients who present late could have avoided surgery had they had the benefit of immediate initiation of wound care and hand therapy by established protocols.

In conclusion, prevention is the first line of defense when dealing with treadmills and other exercise equipment. Unfortunately, based on data from the Consumer Product Safety Commission, the occurrence of these injuries in children does not appear to be on the decline. Logically, the burden of prevention falls equally on treadmill manufacturers and children's parents and guardians. When these injuries do occur, immediate and vigilant wound care and hand therapy appear to afford the best opportunity to achieve a good outcome. Delayed initiation of these treatments seems to correlate with a higher incidence of surgery.

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