Waterslide exit velocities, user behaviours and injury prevention - Jenny Blitvich

Authors: Jenny Blitvich and G. Keith McElroy

Affiliation: School of Human Movement and Sport Sciences, University of Ballarat

Contact: PO Box 663, Ballarat, 3353

j.blitvich@ballarat.edu.au

ph 03 5327 9690

fax 03 5327 9478

The popularity of waterslides is evidenced by long queues of pool patrons waiting their turn to descend slides at aquatic centres on a warm summer's day. Centre managers attest to their role in increasing attendance numbers at complexes (1), with waterslide users clearly enjoying the slides (2). However, with the introduction of water slides comes the risk of injury, and steps are required to minimise this risk.

In Australia, Australian Standards AS 3533 Amusement Rides and Devices applies to waterslides. AS 3533 Part 1: Design and Construction relates to aspects such as stairways/walkways/platforms; surfaces; pump location and design of the slide. Part 2: Operation and Maintenance includes a section on supervision, in specific relating to spacing of riders (3). It states:

- 4.2.4.1
    - (b) Order and spacing
        - (ii) "the dispatching of riders at no less than a minimum spacing which has been established as safe by exhaustive testing and may be signalled by an automatic light or similar device"

The Guidelines for Safe Pool Operations, published by The Royal Life Saving Society – Australia, also contains advice with regard to waterslides. (4)

Waterslide use can result in injury. The typical categories of injury are dental injury (most authors) head and face injury, especially when travelling at speed (5), cuts, abrasions, bleeding noses (6) and fractures, including spinal injuries (7). While the majority of these injuries are minor, a small proportion are serious, including vaginal injury (8) and spinal injury (7, 9).

Poor design, poor construction and inadequate management are considered to be the causes of injury. (6). Gordon and Stevens (10) identified several specific causes of injury:

- collisions with other users, especially when riders form a 'chain'
- contact with the edge of 'tube' or splash pool
- slide design (one slalom slide with a 45° dip followed by a sharp right turn resulted in 68 left eyebrow injuries out of 135 injuries treated over one summer).

For slides where the splash pool is lower than the lip of the slide, increased injury is observed because riders drop into the pool more heavily (10), when compared to slides where the lip of the slide is underwater.

Slide design can be addressed with appropriate modelling and analysis (11). With adequate care with design, incorporating computer-aided modelling, analysis and design technology, engineers are able to test effectively slides in a virtual environment, ensuring safety prior to construction. Recent advances in computer-aided design should enable newly constructed water slides to have the best safety features incorporated in their design.

However, even in recent times, sound principles have not always resulted in best practice. Ball (12) investigated a slide which used a traffic light system to indicate when it was safe for the next rider to commence their descent. It was found that this method was not satisfactory in times of heavy usage. Even when following the traffic light cues, occasional collisions still occurred. It was noted that patrons and lifeguards implemented voluntary injury prevention strategies at these times, and did not rely fully on the traffic light system.

Similarly, even waterslides with excellent design features need to be maintained in excellent condition and managed appropriately if injury risk is to be minimised (13). Mittelstaedt (1) provides a practical list of guidelines for water slide users, waterslide lifeguard instructions and water slide management.

Current Study

In this study, a waterslide complex at a large regional aquatics centre was observed during an afternoon on a hot summer day. Two slides, one open and one enclosed, terminated in a common stand alone splash pool. Two hundred and eighty-eight water slide descents from the open slide were observed, including a 30-minute non-fee session. Velocity was measured by radar as users exited the slide in 267 of the descents. Side view and front view video recordings were made for assessing body position of slide users.

Findings

Velocity on exit ranged from 1.69 m/sec (6.1 kph) to 5.63 m/sec (20.3 kph). These velocities are in excess of those considered by Stone (14) to be sufficient to dislocate (1.2 m/sec) or crush (2.4 m/sec) cervical vertebrae. Hence, there is potential for serious (catastrophic) injury should the head impact a solid object.

Velocities varied with the body position of the user, and with what could be described as their level of confidence. Whilst signs were present indicating that users should be seated and facing forward when descending the slide, various behaviours were observed. Table 1 provides a summary of findings.

Table 1. Velocity and Body Position

Body Position	Maximum Velocity	Minimum Velocity	Average Velocity	Number of Descents
Kneeling	5.64	2.47	3.930	7
Standing	5.55	2.64	4.22	5
Feet first on back	5.33	2.17	4.00	24
Sitting	5.28	1.72	3.27	152
Head first on stomach	5.22	2.44	3.93	52
Feet first on stomach	4.78	3.28	4.04	3
Head first, lying on back	4.44	2.66	3.67	16
Side on	4.28	2.94	3.58	7
Sitting backwards	1.69	1.69	1.69	1
Total				**267**

The highest exit velocity was observed during a kneeling descent. On this occasion, the slider descended the slide in a kneeling position but at the end of the slide performed a dive into the splash pool. This behaviour should be considered to be of high risk. The splash pool is relatively small in size, and not particularly deep. It is not beyond the realms of possibility that impact could be made with either the pool bottom or the opposite side wall of the splash pool. This behaviour should be forbidden.

The highest average velocities were achieved during standing descents, where only the feet were in contact with the slide. Only 5 standing descents were observed, but these occurred during the 'free session' when slide usage was at its greatest. Descending in a standing position increases the possibility of overbalancing, and could easily result in injury.

Head first descents provide little or no protection of the head and neck, and reached velocities sufficient to cause catastrophic spinal cord injury should impact occur. Except in specifically designed slides and splash pools, head first entries should not be permitted. Appropriate design features to permit head first entries would include adequate depth and a relatively large proportion of the final section of the slide gradually sloping underwater, in order to progressively reduce the exit velocity (15).

More than 50% of the descents were in a seating position. Sitting descents provide good vision, sizeable contact with the slide, a slower descent and upon water entry the slider's velocity is quickly decreased because the body position provides considerable frontal resistance. This body position should be encouraged.

Conclusion

Waterslides can provide great enjoyment for aquatic centre patrons. However, it is vital that appropriate steps are taken to prevent injury. Careful design is required to ensure risk minimisation. Slides must be maintained in excellent condition. Best practices in supervision must be applied, specifically through:

- adequate time gaps between users
- appropriate body position during descent (sitting, facing forward is recommended)
- effective application of waterslide rules through conscientious lifeguard supervision, with supportive centre management.

With suitable injury prevention and risk management strategies, complexes with waterslides can enjoy the increased patronage that accompanies them and water slide users can safely participate in this recreation activity.

References

1. Mittelstaedt A. Play it safe! Don't install a new water slide without installing new safety precautions. Aquatics International 2000(March):40-41.

2. Aquatics International. Aquatics International's 1996 Best New Slides and Rides. Aquatics International 1996(Sep/Oct):35-37.

3. Australian Standards. AS 3533.1 Amusements rides and devices, Part 1 Design and Construction. Sydney: Standards Australia International; 1997.

4. Royal Life Saving Society - Australia. Guidelines for Safe Pool Operation. Melbourne: RLSS-A; 2001.

5. Malpass CA, Schuman SH, Sobczyk R. Waterslide Injuries. Annals of Emergency Medicine 1981;10:360-363.

6. Stokes AN. Waterslide accidents. New Zealand Dental Journal 1985;81:114-116.

7. Baggoley C, Radford A. Waterslides - The new recreation. A study to determine prospects for injury prevention. Australian Council for Health, Pysical Education and Recreation 1983;Winter:15-18.

8. Niv J, Lessing JB, Hartuv J. Vaginal injury resulting from sliding down a water chute. American Journal of Obstetrics and Gynecology 1992;166:930-931.

9. Centres for Disease Control. Injuries at a water side - Washington. Morbidity and Mortality Weekly Report 1984;33:379-387.

10. Gordon CJ, stevens KLH. Waterslides - are safety standards sliding? Archives of Emergency Medicine 1988;5:216-222.

11. Joo S-H, Chang K-H. Design for safety of redreational water slides. Mechanical Structure and Machines 2001;29(2):261-294.

12. Ball DJ. Some observations on waterslide injuries. Injury Prevention 1998;4:225-227.

13. Mills-Senn P. Keep an eye on your slide. Aquatics International 2001;October:20-26.

14. Stone RS. A rationale for rating pools with diving boards. (Arthur D. Little Study No 4). Cambridge, Ma: Arthur D. Little Inc; 1981.

15. Turner A. Waterslides - The North American experience. Leisure Management 1988;8730-32