A STUDY OF USING BOXING GLOVES WITH INFLUENCE-DAMPING PROPERTIES

ROSELIN JOSEPH
Research Scholar, Dept. of Physical Education,
Sri Satya Sai University of Technology & Medical Sciences,
Sehore, Bhopal-Indore Road, MadhyaPradesh, India

Dr. MINAKSHI PATHAK
Research Guide, Dept. of Physical Education,
Sri Satya Sai University of Technology & Medical Sciences,
Sehore, Bhopal-Indore Road, MadhyaPradesh, India

ABSTRACT

Design methods were employed over a 5-year period to develop boxing gloves capable of substantially buffering impact forces delivered to an opponent, thereby permitting safer boxing. Multiple concepts were explored, with sophistication of prototypes gradually increasing. The protypes underwent both quantitative laboratory testing and qualitative evaluation in the field. The laboratory testing methods were evolved over time to enhance test reliability and ecological validity. Feedback from the laboratory and field trials was highly instrumental in guiding the process of glove development. It was eventually found that, compared to standard boxing gloves, pneumatic gloves with sealed bladders were effective in reducing peak impact forces and peak rates of force development when impact magnitudes were low to moderate but not when they were high. By contrast, pneumatic gloves incorporating a bladder enabling air exchange with the external environment were protective across the entire range of impact magnitudes likely to be encountered in boxing. These gloves are configured differently from standard gloves in terms of the positioning of the first relative to the glove padding, but now have close visual resemblance to standard gloves. The aesthetics of the gloves have proven critical to their acceptance. Wearer comfort is also vital and, although we extensively pursued the concept of thumb less gloves, we finally deemed it necessary to include separate thumb compartments to accommodate user advice. There is scope for further glove refinement, but recent experience indicates that the latest version is currently sufficient for use in modified boxing programs that emphasise safety, with such targeted contextual sufficiency realising a fundamental aim commonly associated with projects employing the design approach. Small batches of the gloves have recently been manufactured to cater for modified boxing programs.

KEYWORDS: Boxing Safety, Modified Boxing, Pneumatic Boxing Gloves, Protective Equipment for Boxing, Sport Design

INTRODUCTION

Boxing has a presence in almost every nation throughout the world [1]. It has been included in all but one Summer Olympic Games since 1904, but has been subject to criticism on medical, ethical, legal and sociological grounds [2]. In 2003, a paper published in the British Columbia Medical Journal included the following: "In boxing, the ultimate achievement is to knock somebody out. And to knock somebody out is to injure his or her brain … Every year we read of some poor boxer who collapses and dies after a boxing bout as a result of repeated blows to the head. Moreover, we know … that blows to the head have a cumulative and devastating effect. Twenty years on and the commonly referred to condition of being punch drunk (is) all too easy to recognise … slurred speech, unsteady legs, lapses of memory, violent tendencies and the general appearance of having had a few too many" [3]. A decade later, the eminent neurologist and geneticist John Hardy expressed the view that: "Boxing is a special case. No other sport has the express goal of causing injury to the brain. That is certainly the aim of professional boxing. Even in amateur boxing blows to the head are crucial … No doubt I will be called a killjoy for espousing the view that boxing should be banned … I would return the charge: nothing can be more killing of joy than personality changes, violence, substance abuse and dementia" [4]. Such views cannot be lightly dismissed. Between 1890 and 2007, there was an average of more than 10 deaths per year from acute injuries received in boxing, with amateur boxers accounting for almost a quarter of these [5]. Several studies have demonstrated structural pathology in the brains of boxers, including changes resembling those associated with Alzheimer's disease [6]-[12]. Biochemical indicators of neuronal damage have been detected in amateur boxers but not age-matched controls [13] [14]. Boxers also show a relatively high incidence of electro-encephalographic (EEG) abnormalities and deficits in cognitive function. Boxing-related injuries were responsible for a total of 437 British Army medical unit admissions from 1969 to 1980. Head trauma accounted for ~68% of these, but there were 20 admissions for trunk injuries including rib and vertebral fractures, and 13 for kidney and pelvic organ injuries that required an average hospitalization time of 6.2 days. Between 1990 and 2008, there were 165,602 presentations to United States Emergency Departments for injuries sustained in boxing, with more than 37,000 of these relating to head or neck injuries. Legal experts have argued that boxing consists of activities that in other contexts would constitute criminal assault and have raised issues relating to the legitimacy of participant consent. Sociologists have claimed that boxing has negative effects by overtly glamorizing and rewarding violent conduct and is exploitative of vulnerable young people. There is potential to address objections to boxing through modifications to the rules and equipment. Common suggestions include removal of the head and neck from the target area and the development of gloves capable of substantially reducing impact forces delivered to an opponent. Considerable doubts have been expressed as to whether the boxing community would ever be amenable to such changes [3], since it is believed that the visual, emotional and cultural appeal of the sport to that community is largely tied to its inherent risks. This belief is partially supported by the fact that since the 1890s, there have been more than 20 patents lodged for gloves aimed at markedly decreasing impact forces, but none has led to widespread or sustained adoption of a new glove design.

INITIAL ATTEMPT TO REPRODUCE PNEUMATIC GLOVES

The one scientifically assessed glove aimed at impact damping was produced by a Finnish physician, Lyderik Löfgren, more than 60 years ago. Like many earlier designs, it incorporated an air-filled bladder in place of standard glove padding. Laboratory testing showed that, compared to conventional gloves, it substantially reduced acceleration of a struck mass attached to a pendulum. An effort to reproduce that glove seemed a logical starting point for our work, although inability to locate relevant drawings made it a challenging task. After discussion with engineers from RMIT, we initially engaged an external consultant to manufacture a few pairs of pneumatic gloves with characteristics resembling those described by the original inventor. The external consultant was an enthusiastic modified boxing participant with a strong background in technological innovation. He approached the glove development with zeal and during the second half of 2013 produced some early prototype gloves that contained open-cell foam in place of standard glove padding. The surfaces of the foam were coated with rubber. There was a valve that allowed air to be pumped into or extracted from the foam structure to adjust its internal air pressure. As an additional feature evidently not included in the original pneumatic gloves, a small hole was made in the rubber coating to permit air release from the foam structure upon impact, in keeping with a concept patented by Carrillo. The form of the pneumatic gloves was quite similar to that of standard gloves (Figure 1).

The testing consisted of dropping samples of the different materials from selected heights on to a Kistler load cell that measured the impact profiles. Additionally, an INSTRON system was used to enable impact force measurements when the different samples were accelerated to known velocity over a set distance. The air-filled foam was tested both with the air hole open and occluded. The experimental set-up is shown in Figure 2.

Figure 1. Front and side views of early prototype pneumatic gloves designed to resemble those produced six decades ago in Finland

Figure 2. Equipment set-up for drop-weight and INSTRON testing of prototype gloves and air-filled foam materials

The drop-weight and INSTRON tests produced highly repeatable results for any particular material. The prototype foam structure was softer than standard glove padding. The peak impact force produced when it was attached to a mass of 2.076 kg and dropped from a height of 0.7 metres on to a load cell was lower than that measured when the same procedure was applied to the standard padding and to a standard intact boxing glove. The situation was reversed, however, when the drop-weight test was performed from a starting height of 1.1 metres, presumably because the prototype material became quite hard once its maximum deformation had occurred. Similar findings were obtained from the INSTRON testing, which indicated that the prototype material offered a protective effect only up to a peak impact force of ~500 Newtons (N), beyond which point the standard glove padding performed better. The air hole that had been included in the prototype structure had almost no effect in reducing the peak impact force, since the time to peak force was too short for any substantial air release to occur.

ALTERATION OF FIST POSITION RELATIVE TO GLOVE PADDING

With the endeavour to produce effective pneumatic gloves at least temporarily on hold, focus was directed to another idea that had arisen during initial discussion as to how impact buffering might be achieved. This idea concerned the possibility of reducing peak impact forces through alteration of the positioning of the fist relative to the main section of glove padding. We initially conducted some informal trials amongst ourselves by sparring with standard boxing gloves but employing a novel fist position within the gloves. Based on our subjective impressions of the effect, a decision was made to further explore the concept. With assistance from the Brisbane-based company HART Sport Pty Ltd., prototype gloves were produced that required the whole closed fist to be placed into the compartment beyond which the fingers would usually extend (in contrast to the normal process of placing an open hand into the glove and then closing the fist). The portion of the glove that would otherwise contain the fingers was therefore left free, increasing both the thickness of padding in front of the knuckles and the scope for that padding to flex upon impact. The new gloves were manufactured in vibrant red and blue colors to maximise their visual appeal. After informal tests in training settings, they were used in a 7-bout modified boxing event held at the PCYC in March 2014 (Figure 3).

All but one of the contestants subsequently completed an anonymous on-line survey. There was unanimous agreement that the gloves reduced impact forces compared with standard gloves. Four athletes indicated that the degree of impact buffering was substantial, eight considered it moderate, and one thought it slight. Four athletes said that they did not enjoy using the prototype gloves, whereas three greatly enjoyed the experience. The remaining six athletes were neutral. Four athletes were either satisfied or very satisfied with the comfort of the gloves, five were neutral, three were unsatisfied and one was very unsatisfied. In consideration of the formal feedback, and of casual comments subsequently made by the trial participants, we perceived that we were still far from realizing our over-riding project goal.

Figure 3. Modified boxing contest with gloves incorporating altered relationship between fist position and padding. Fist was contained in area of glove shown by white circles

HIGHLY DEFORMABLE GLOVES

We noted the ability of air-containing party balloons to buffer impact forces as a result of their high elasticity and deformability and imagined that there might be potential to develop boxing gloves embodying these characteristics. It seemed possible that a balloon-like structure contained in a compartment much more elastic than standard glove leather or vinyl could form the “padding” of the glove, with the whole fist positioned behind it in a manner consistent with that tried in the above HART Sport gloves. With the emergence of this concept, the project moved into a new phase in which we began constructing prototype gloves ourselves rather than arranging for established manufacturers to implement designs. As a first step, we evaluated several different air bladders with a view to finding one that was reasonably balloon-like but resistant to bursting when exposed to high impact forces. On advice from HART Sport, we eventually selected a Size 1 latex soccer ball bladder manufactured by Enkay [India]. We then cut off the end-section (i.e. the finger section) of a standard training glove and replaced it with a sewn-on, stretchable lycra bag with a sealable opening for insertion of the bladder, which could then be inflated. A second lycra bag could subsequently be pulled over the whole complex to confer stability and shape and to enclose the thumb, effectively making the glove thumbless as has been recommended by medical authorities. The construction process is illustrated in Figure 4.

Figure 4. Construction of highly deformable prototype gloves

In initial play amongst ourselves, the new gloves seemed subjectively to be have greater impact-buffering capacity than our previous prototypes. We produced multiple pairs in red and blue colors, and in April 2014 they were used at modified boxing (Box' Tag) Police & Emergency Services Games. There were mixed reactions from the contestants. Negative comments on the "look" and "feel" of the gloves were common. On the other hand, all 22 of the Sydney competitors and 11 of 14 Melbourne competitors perceived that the gloves reduced impact forces, with the majority rating the reduction as large. There were some reports that, when impacts were forceful, the bladders could occasionally 'turn under', causing impact to be made with only slightly padded knuckles. In later investigation of possible reasons for these reports, it became clear that inappropriate positioning of the hand within the glove (particularly through extension of the fingers) could lead to the bladder being pulled downward into a position entailing a risk that it would not be the first point of contact with the opponent. To overcome this problem, we subsequently produced "inner" gloves that prevented finger extension.

REFINEMENT OF HIGHLY DEFORMABLE GLOVES

At the beginning of 2015, we gave considerable further thought to possible reasons for reports that buffering of impacts by the prototype gloves combining the bladders and lycra covers occasionally seemed to fail. Displacement of the spherical bladder from its intended position was recognized as one likely cause of the problem. It was also apparent that even when the bladder was in position, hooked punches (as opposed to straight punches) could sometimes result in the opponent being contacted by the back of the glove in the area behind the bladder, meaning that protection afforded by the bladder would not occur.

We therefore implemented several changes to the gloves. We covered the area behind the bladder with a 2.5 cm thick layer of medium-density open cell foam. The top of this layer extended to half-way up the bladder and had two arms that extended forward to provide a circular ‘cradle’ for bladder support. The upper edge of the foam was cut to a shape that enabled efficient seating of the bladder. The changes had the disadvantage of adding to the bulk of the gloves (Figure 5) but were perceived as addressing important deficiencies of the prior prototype. In April 2015, two of us and a colleague with a background in kick-boxing took part in a trial in which each person used the new prototype gloves, conventional 12oz (Std 12oz) gloves of the type used in competition by amateur boxers in the heavier weight divisions, and conventional 16oz (Std 16oz) gloves such as those commonly used by boxers in sparring to deliver a series of subjectively light, medium and heavy impacts to a commercially available apparatus designed and built by the Institut Für Angewandte Trainingswissenschaft [Institute of Applied Training Science] in Leipzig, Germany, specifically for measuring punch characteristics. This apparatus, located at the AIS in consisted of a wall-mounted force plate covered by a pad with a thickness of 290 mm including a leather covering, multiple foam layers, two layers of plywood board and a 20 mm thick aluminium plate to which the load cell was attached. The pad had a frontal surface of 330 mm square and at the point of maximum width it was 460 mm square. The aluminium plate at the back of the pad was 350 mm square. The apparatus, which is shown in Figure 6, incorporated a two-beam laser system that enabled measurement of pre-impact glove velocities. The beams were positioned 44 mm apart and very close to the target area of the pad.

Figure 5. Prototype low-impact gloves with additional foam added to perimeter of glove to increase protection against impacts delivered with a part of the glove other than the bladder. The white areas at the top of the gloves are electrically conductive patches that formed part of automated scoring technology used in Box’ Tag

Figure 6. Apparatus at the Institute of Sport, for measuring punch characteristics

A BREAKTHROUGH: BUILDING OF GLOVES AROUND BLADDERS

Shortly after the laboratory testing at the AIS it was decided that, instead of using commercially available training gloves as a base and adapting them to enable accommodation of a bladder, we should focus on the bladder as the core element of our approach and work out how best to build a glove around it. In retrospect, this decision constituted a major advance in the project. It reduced material costs as the need to purchase training gloves was eliminated, and it also removed constraints as to how various glove components could be arranged as part of the assembly process. Initially, cardboard cut-outs of a glove "frame" were produced to enable experimentation that culminated in determination of optimal shape and dimensions. Once the characteristics of the frame had been finalized, a cut-out consisting of 0.5 mm thick rubber was made. Velcro "hook" material was then sewn on to the bottom section of the frame. To one side of it, a strip of elastic was sewn. To the other, a section of Velcro "loop" material covered with grey ripcord fabric was attached. The frame was then flipped over and a rectangular section of 2 cm thick open cell foam was glued to most of its surface. A triangular strip of the same open cell foam was glued to the rubber and the upper surface of the rectangular strip. The outer ends of the rubber frame were then brought together to create a circular, slanted cradle for the bladder. A notch was cut in the frame to provide access to the bladder valve. After placement and inflation of the bladder, a lycra bag was pulled over the whole unit. The elastic and Velcro materials formed a secure wrist strap (Figure 7).

Figure 7. Overview of the construction of the first prototype low-impact gloves designed around the bladder

The glove made in this way had all the features of the previous prototype but its outer surface was smooth and it was much shorter and sleeker. It elicited a positive reaction from participants in the modified boxing program at the PCYC and, with help from an Industrial Design student from the few Minor Improvements was made in response to their feedback. The impact-buffering effects of the glove were subjectively perceived as substantial. Consequently, several pairs of the gloves were produced to permit more comprehensive field trials. It was found that after delivery of multiple moderately forceful impacts, creasing of the glove frame began to occur close to the bottom of the bladder. This area of the frame obviously would be subject to considerable compressive and shear forces during impact. Investigation of the cause of the creasing problem suggested that it could be due partly to a tendency for the triangular section of foam forming the bladder cradle to become separated from the main (rectangular) section of the glove padding. We therefore made some new prototypes in which the foam element consisted of a single piece, instead of two pieces glued together. We also added a second layer of rubber to the glove frame to increase overall frame strength.

CONCLUSION

We subsequently showed the latest prototype gloves to an internationally renowned boxing coach who has more than 40 years of experience in the sport. After trying them on, he opined that their acceptance by serious boxers remains very unlikely, but did suggest that they could have applications during early learning of boxing skills. The gloves were also shown to the Head Coach of the Sydney club that has run a combined boxing and modified boxing program for many years and has been the site of some of our glove trials. He too put on the gloves and commented that they are now visually attractive, comfortable to wear, and highly suitable for use in the modified boxing context. Based on initial success of the modified boxing program in India, Boxing was able to obtain further funding that now guarantees continuation of the program until the end of September 2018. Encouraged by these developments, Boxing is now seeking to expand modified boxing activities in its domestic domain. In April 2018, it contracted Paramount Enterprises to produce 60 pairs of ARLI gloves for export to cater for this initiative and the consignment has now been delivered. Stellen Studio continues to manufacture ARLI gloves in small batches each incorporating minor alterations as part of ongoing research efforts aimed at gradual glove improvement. It is envisaged that this will enable regular updating of blueprints provided to Paramount Enterprises for larger scale production.

REFERENCES

[1] International Boxing Association. Boxing: A Universal Sport [Internet]. International Boxing Association National Federations. https://www.aiba.org/national-federations/

[2] Perkins, P., Hahn, A., Lucas, R. and Keegan, R. (2014) The Boxing Conundrum: Is There a Place for a New Variant of the Sport? Journal of Research in Humanities and Social Science, 2, 9-25.

[3] Smillie, M. (2003) There Is No Sport Like Boxing. British Columbia Medical Journal, 45, 473-474.

[4] Hardy, J. (2013) The Ignoble Art. NewScientist, 219, 26-27. https://doi.org/10.1016/S0262-4079(13)61991-0

[5] Svinth, J. (2007) Death under the Spotlight: Analyzing the Data. Journal of Combative Sport, 2007, 1-19.

[6] Roberts, G.W., Allsop, D. and Bruton, C. (1990) The Occult Aftermath of Boxing. Journal of Neurology, Neurosurgery & Psychiatry, 53, 373-378. https://doi.org/10.1136/jnnp.53.5.373

[7] Lundberg, G. (1993) Medical Arguments for Nonparticipation in Boxing. In: Medical Aspects of Boxing, CRC Press, Florida USA, 11-15.

[8] Unterharnscheidt, F. (1995) A Neurologist's Reflections on Boxing. V. Conclude Remarks. Revista de Neurologia, 23, 1027-1032.

[9] Zhang, L., Heier, L.A., Zimmerman, R.D., Jordan, B. and Ulug, A.M. (2006) Diffusion Anisotropy Changes in the Brains of Professional Boxers. American Journal of Neuroradiology, 27, 2000-2004.

[10] Pineda, P. and Gould, D. (2010) The Neuroanatomical Relationship of Dementia Pugilistica and Alzheimer's Disease. Neuroanatomy, 9, 5-7.

[11] Cabanis, E.-A., Iba-Zizen, M.-T., Perez, G., Senegas, X., Furgoni, J., Pineau, J.-C., et al. (2010) Boxing: Traumatology and Prevention. Bulletin de l'Académie nationale de médecine, 194, 1219-1236.

[12] Bailey, D.M., Jones, D.W., Sinnott, A., Brugniaux, J.V., New, K.J., Hodson, D., et al. (2013) Impaired Cerebral Haemodynamic Function Associated with Chronic Traumatic Brain Injury in Professional Boxers. Clinical Science, 124, 177-189. https://doi.org/10.1042/CS20120259

[13] Neselius, S., Zetterberg, H., Blennow, K., Marcusson, J. and Brisby, H. (2013) Increased CSF Levels of Phosphorylated Neurofilament Heavy Protein Following Bout in Amateur Boxers. PLoS ONE, 8, e81249. https://doi.org/10.1371/journal.pone.0081249

[14] Tanriverdi, F., De Bellis, A., Battaglia, M., Bellastella, G., Bizzarro, A., Sinisi, A.A., et al. (2010) Investigation of Antihypothalamus and Antipituitary Antibodies in Amateur Boxers: Is Chronic Repetitive Head Trauma-Induced Pituitary Dysfunction Associated with Autoimmunity? Eur J Endocrinol, 162, 861-867. https://doi.org/10.1530/EJE-09-1024