PUNCHING IMPACT EFFECT OF THE KARATE, BOXING, AND THE THUMBLESS BOXING GLOVE

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Only limited information is available relative to the impact characteristics of the foam karate glove, the conventional boxing glove, or the recently developed thumbless boxing glove. It was therefore the main problem in this investigation to determine the comparative effects on fist velocity and resultant momentum of a heavy bag when punched by low, intermediate, and high skill level subjects wearing 1) no glove, 2) the foam karate glove, 3) the conventional boxing glove, and 4) the thumbless boxing glove.

Considering the contact involved, intentional or otherwise, the injury rate is relatively low for karate and boxing when compared to other sports. Yet, serious injuries do occur. The karate injury rate is about 34% with 0.02% being serious and only four deaths have been reported. In boxing, 335 deaths were reported between 1945 and 1979 and considerable negative publicity regarding brain damage from repeated head impact has emerged recently.

Forces sufficient to cause accelerations of 80 g (784 N at about 8 ms contact time) have been established as the concussive or knockout level according to the Wayne State Tolerance Curve. Comparable forces applied to the body can cause ruptures, contusions, and other injury to organs of the trunk, depending on the impact site. Newtonian principles of momentum and energy conservation using High-Speed Cinematography and Force-Time apparatus have been employed by several researchers to estimate force levels for various types of punches and strikes. Walker (1975) estimated mathematically that 3,200 N (719 lbs) would be necessary to break a brick, which is a common practice in karate demonstrations. Walker (1975) further estimated punch impulses to be on the order of 4,900 N, based on a linear fist velocity of 7 m/s and the use of an estimated arm mass of 7 kg with a 10 ms contact time. Nakayama (1966) compared the stepping punch with the standing punch and determined average forces from cinematographic studies to range from about 170 to 700 kg. Other investigators have reported similar findings. This is a considerable amount of force since only about 1,100 N is required to fracture a mandible (Patrick and Sato, 1970).

The use of safety pads and gloves is an effort to attenuate forces involved in impact from punches and kicks and thereby reduce injuries to the person initiating impact and the person being hit. Few studies have addressed the ability of punching gloves to lessen impact forces.

Studies commissioned by the Canadian government came to some enlightening conclusions relative to boxing gloves. Dessureault and Therrien (1981) determined that large force and weight variations existed between gloves of supposedly the same weights. The Canadian study also found that gloves lost almost 50% of their force absorption ability after 11 impacts and that some gloves had been used in up to 100 fights.

TABLE 1
INJURY RATES IN VARIOUS SPORTS *

SPORT	INJURY LEVEL (%)
Football	81.0
Wrestling	75.0
Softball	43.7
Karate	34.0
Track and Field	33.0
Basketball	30.5
Volleyball	9.8

* Summarized from Carrick & Requa (1981) and Birrer & Birrer (1982).

TABLE 2
FATALITY RATES FOR VARIOUS SPORTS *

SPORT	FATALITY RATE (per 1000)
Horseracing	12.80
Sky Diving	12.30
Hang Gliding	5.60
Mountaineering	5.10
Scuba Diving	1.10
Motorcycle Racing	0.70
Football	0.30
Boxing	0.13

* Summarized from AMA (1983).

Hodgson and Thomas (1981) compared the conventional boxing glove with the newly developed "Thumbless Glove" at sub-concussive and concussive levels of impact. They found a 55% difference in the Severity Index (S.I.) favoring the Thumbless glove at the lower levels of force and only 19% difference at the concussion level.

Smith and Hamill (1985) compared high, intermediate, and low skilled punchers using the bare fist,the conventional boxing glove and the foam karate glove and determined that high skilled punchers were able to generate more momentum with their punches than intermediate or low skilled subjects with no differences in fist velocity and supported a previous study by Smith (1977) and Plagenhoef (1971). This supported the contention that high skilled karate participants could better coordinate body mass into the punch and supported the concept known in karate as focus as well as the force summation principle.

Because no Skill Level-Glove Type interaction was present and bag momentum levels were greater when punchers wore the boxing glove than when bare fisted, Smith (1985) concluded that the boxing glove actually facilitated harder punches, rather than attenuate the forces involved.

METHOD

In the present study five low (white belt), five intermediate (green belt), and five high skilled (black belt) subjects were randomly selected to punch a heavy bag with the reverse or counter-punch. The main difference between subjects, as groups, was that the high skilled group had trained longer.

TABLE 3
MEANS AND STANDARD DEVIATIONS FOR SUBJECT DESCRIPTIVE INFORMATION BY SKILL LEVEL

Skill Level	Age (yrs)		Years Training		Height (cm)		Weight (kg)	
	X	SD	X	SD	X	SD	X	SD
High	30.40	9.71	10.70[a]	6.08	172.60	6.40	72.50	12.34
Intermediate	23.60	7.13	1.20[b]	0.50	168.42	6.83	65.05	9.26
Low	20.80	2.38	0.34[b]	0.15	176.52	10.02	81.00	16.07

* Means with the same superscripts are not significantly different ($p < .05$).

That High Skill subjects did not impart more momentum to the bag than lower skilled participants did not agree with Smith and Hamill's (1985) finding in a similar study. Smith (1985) concluded that since greater momentum was imparted to the bag by higher skilled subjects at similar velocities, then more mass must have been coordinated into their punches. This lack of agreement may be due to the statistical relationship of the increased number of Glove Type conditions or an actual absence of differences in Bag Momentum among the skill levels. The proximity of the statistical probabilities to the cutoff level, in both studies, indicates that the protocol needs to be replicated several times to generate conclusive evidence to answer the question of whether High Skilled subjects can, in fact, coordinate their movements to involve more mass in the punch than lower skilled punchers.

Age, Height, and Weight characteristics were not different. The Karate Glove was a Pro Brand karate glove made from Type MLC Ensolite, which is manufactured by the Uniroyal Corporation. This molded foam has a density of 3-4.5 lbs/cu ft, and a 25% compression-resistance factor of 1.5-3 lbs/cu ft and was 3 cm thick at the impact surface. The Boxing Glove was a Model 2210 Official AAU boxing glove. This glove was composed of a hair pad sandwiched between two layers of foam and covered with a leather sheath. Its thickness was 4 cm at the impact area. The Thumbless Glove tested was a Model 2810 Thumbless Boxing Glove which was also 4 cm thick at the impact surface. Specific impact test and specific material composition information for neither boxing glove was available from the manufacturer.

A 3 X 4 Multivariate design with Duncan's Multiple Range Test follow-up procedure was used for analysis. Independent measures were Skill Level (Low, Intermediate, and High) and Glove Type (Bare Fist, Karate Glove, Boxing Glove, and Thumbless Glove). Dependent variables were Fist Velocity 10 ms prior to impact and Bag Momentum 100 ms after impact.

Subjects were dressed in shorts and had joint centers marked. Three trials were recorded cinematographically at 100 frames per second for each subject punching a 33.45 kg bag with each glove type and with the bare fist. Average scores on Fist Velocity and Bag Momentum for the three punches of each condition were used for analysis.

RESULTS

No Skill Level, Glove Type, or Interaction significant effects were found on the Fist Velocity dependent measure. With Bag momentum as the criterion for comparison, as indicated in Table 4:

TABLE 4
ANALYSIS OF VARIANCE FOR BAG MOMENTUM CRITERION

Source	df	SS	MS	F	p
Skill	2	4383.08	2191.54	3.63	0.053
Subject (Skill)	12	7235.05	602.92		
Glove Type	3	1350.81	450.27	4.40	0.0097*
Skill Level * Glove Type	6	524.86	78.48	0.86	0.5363
Subject * Glove Type (Skill)	36	3681.28	102.23		

* $p < .05$

No Skill Level effects were detected, but the Glove Type did make a difference. Bag Momentum levels were higher with the Thumbless Glove and Boxing Glove than the Bare Fist condition and no difference was perceived between the Bare Fist and the Karate Glove or the Karate Glove and the Thumbless Glove. There was no interaction effect with Skill Level and Glove Type.

TABLE 5
FIST VELOCITY AND BAG MOMENTUM MEANS AND STANDARD DEVIATIONS
BY SKILL LEVEL AND GLOVE TYPE

	Fist Velocity (m/s)		Bag Momentum (N-s)	
Skill Level	X	SD	X	SD
High	12.32	1.25	60.73	17.06
Intermediate	11.64	2.53	42.13	15.69
Low	10.56	2.01	43.10	11.65
Glove Type				
Bare Fist	11.03	1.96	42.01[a]	18.66
Karate Glove	11.84	2.10	46.38[a,b]	17.40
Thumbless Glove	11.54	2.00	52.52[b]	15.61
Boxing Glove	11.57	2.43	53.73[b]	15.35

NOTE: Different superscripts indicate statistical significance ($p < .05$).

DISCUSSION AND APPLICATIONS TO SPORT

Striking Mass ranges were similar to those found by Smith in 1977 and 1985 (3 - 5 kg) and Plagenhoef in 1971 (4.5 kg), though different from the 7 kg total arm mass suggested by Walker (1975). It would appear that models utilizing the arm mass would be somewhat less than adequate when compared to experimental evidence.
not be totally connected to the rigid skeletal force imparting structure and therefore would not be considered as part of the impacting mass.

The fact that the Boxing Glove and Thumbless Glove conditions imparted more momentum to the bag than the Bare Fist was expected and consistent with Smith and Hamill's (1985) work. The cushioning effect of the Boxing and Thumbless Gloves probably allowed subjects to punch harder without the impending threat of knuckle pain. Higher momentum levels transferred to the bag is indicative of greater acceleration, which has been directly related to brain and tissue damage.

According to the WSTC in which the forces necessary to cause head accelerations sufficient to cause concussion have been adjusted to the mass factor for a head of 5.44 kg (12 lbs), impulse ranges from 34 N-s to 90 N-s (to cover a broad spectrum) would likely cause concussive injury. Since the overall impulse range in this study was found to be from 42.01 N-s to 60.73 N-s, it is evident that none of the punching conditions could be considered "safe" for full-contact karate or boxing competition.

In summary, velocity and force ranges from the present study agreed with related literature on punching. Striking Mass ranges were similar to those reported in experimental studies, about 4.5 kg; but differed from that of the 7 kg total arm mass estimated by Walker (1975) in a mathematical model. Subjects did not differ on fist velocity at impact and no Bag Momentum differences were detected among skill levels. More momentum was transferred to the bag with the Thumbless and Boxing Gloves than with the Bare Fist, though the Karate Glove did not differ from any of the other conditions. Considering human punching capabilities, none of the glove conditions would prevent an opponent from being knocked out, rather this data indicate the gloves would facilitate the opponent being knocked out and therefore seem to benefit the puncher rather than the person being punched.

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