J. Phys. Ther. Sci. 33: 495–498, 2021

The Journal of Physical Therapy Science

Original Article

Basic research on the primary prevention of boxing-related sports injuries with the development of a quantitative motion analysis software

Kouichi Nakamura, RPT, PhD[1)*], Masaki Uchida, RPT, PhD[1)], Tomonori Sato, RPT, PhD[1)]

[1)] *Department of Physical Therapy, Faculty of Health Science, Tokoha University: 1-30 Mizuochi-cho, Aoi-ku, Shizuoka-shi, Shizuoka 420-0831, Japan*

Abstract. [Purpose] To develop a quantitative motion analysis software specific to boxing (Fist Tactics Support) and to verify its effectiveness based on the percentage of hits that land on the participants. [Participants and Methods] A total of 24 male professional boxers were divided into two groups: those who used Fist Tactics Support to analyze fight videos and instituted training changes based on the results (Fist Tactics Support group, 12 participants) and those who did not (control group, 12 participants). The overall percentage of hits that landed on the participants in the fights was compared between the two groups and between pre- and post-intervention. [Results] There were no significant differences between the two groups; however, the percentage of hits that landed on the boxers of the Fist Tactics Support group was significantly lower at post-intervention than at pre-intervention. [Conclusion] The use of scientific analysis results in boxing may facilitate the primary prevention of sports injuries.

Key words: Boxing, Development, Prevention of sports injuries

(This article was submitted Feb. 12, 2021, and was accepted Mar. 26, 2021)

INTRODUCTION

Boxing is an extreme contact sport characterized by the use of minimal protective equipment and punching the opponent's head and abdomen with the goal of knocking down the opponent. Domestic and foreign studies on injuries in professional and amateur boxers have reported various injuries during boxing, including concussions, intracranial hemorrhage, facial lacerations, retinal detachment, orbital floor fractures, nasal fractures, rib fractures, organ damage, and lower back pain[1–8]. In addition, a follow-up study on boxers over 23 years (from 1978 to 2000, when computed tomography was widely performed nationwide) examined acute subdural hematoma (ASH) occurring among 31,808 professional boxing matches sanctioned by the Japan Boxing Commission[5]. The study revealed that 15 out of 45 boxers diagnosed with ASH died. ASH is a leading cause of accidental death in boxing. Boxing involves direct blows to the head; therefore, careful attention must be paid to this aspect. An increasing number of individuals with ASH tend to be saved owing to advancements in medicine. However, instances of ASH have not reduced[7].

One effort toward the prevention of boxing injuries has been the adoption of Olympic-style boxing at the amateur level. This boxing style was adopted after the 1984 Los Angeles Olympics in accordance with the revised International Boxing Association (AIBA) rules where a point system is used instead of trying to knock out one's opponent. The Japanese amateur boxing rules follow AIBA rules. The Japanese amateur rules use an Olympic-style system and seek to enhance safety, e.g., having a ringside physician to stop a fight. Fighters in amateur boxing are required to wear protective headgear. Though protective equipment effectively prevents facial lacerations, scientific evidence of its effectiveness in preventing brain injuries

*Corresponding author. Kouichi Nakamura (E-mail: k-nakamura@sz.tokoha-u.ac.jp)

is lacking[6, 7]. Moreover, though amateur boxing uses a point system instead of knocking out one's opponent, acute brain injuries continue to occur during fights and training, predominantly among high school and university students[6]. Thus, boxers and others involved in the sport must be keenly aware that acute brain injuries cannot be prevented by soley following the rules of a boxing competition and require active steps to prevent accidents from multiple perspectives. Medical personnel in particular should devise and implement methods to prevent injuries instead of concentrating solely upon treatment and return to sports. These methods should be scientific, comprehensive, and incorporate various perspectives.

Thus, in this study, we developed a quantitative motion analysis software specific to boxing (Fist Tactics Support [FTS]). We focused on percentage changes in hits that landed on the participants in fights overall based on the use of this software as basic research to facilitate the primary prevention of sports injuries.

PARTICIPANTS AND METHODS

Participants were current professional boxers (24 males) licensed by the Japan Boxing Commission with a mean age of 22.1 ± 3.3 years and a history of 5.0 ± 2.1 years in the boxing (mean ± standard deviation). This study was approved (approval no. 18-14) by the Research Ethics Committee of Tokoha University. Details of this study were fully explained to all participants who provided written informed consent.

Participants were randomly allocated to a group training alongside FTS (the FTS group) and a group training normally (the control group). All participants used FTS to quantitatively analyze the video of their first fight after starting the study. The total percentage of hits that landed on the participants was determined as a baseline indicator. Results of FTS analysis were fed back to trainers and boxers in the FTS group, and a training regimen was implemented based on those results before the next fight. The control group did not receive any input and was trained normally before their next fight. Video of the second fight after the start of the study was analyzed using similar procedures as for the first fight, and the percentage of hits that landed on the participants in overall fights was determined and compared between groups and pre- and post-intervention.

FTS is specific to boxing and is developed to allow the quantitative assessment of performance with respect to both offense and defense (Fig. 1). In specific terms, aspects of offense and defense to be analyzed are identified based on fight videos. FTS is programmed to assess the choice of defenses for certain types and sites of attacks and whether a hit landed and to quantitatively analyze the number and percentage of hits that landed. The analyses could be performed over time in each round, and FTS is configured to generate a performance assessment for boxers and trainers to readily understand the results.

Statistical analysis of the percentage of hits that landed on the participants in overall fights was performed as follows. Changes in the percentage of hits landed were determined using repeated-measures analysis of variance while considering the following two factors: when hits were recorded (first vs. second fight) and whether FTS was used during training (FTS vs. control). The Bonferroni procedure was used for multiple comparisons. The data were analyzed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA), and the significance level was set to 0.05.

RESULTS

The intervals between fights and the number of rounds for both groups are shown in Table 1. The percentage of hits that landed on the participants in all the fights was compared in terms of "using FTS vs. not using FTS" and "when hits were recorded." The main effect of "using FTS vs. not using FTS" was not observed [$F(0.258)$, $p=0.5877$]. The main effect of "when hits were recorded" was observed [$F(3.567)$, $p=0.02$]. An interaction between factors was not observed [$F(0.322)$, $p=0.8416$]. The multiple comparison test results of "when hits were recorded" revealed that the percentage of hits that landed was significantly lower in the FTS group post-intervention than pre-intervention ($p<0.05$). The pre- and post-intervention comparison revealed no significant differences in the control group ($p>0.05$) (Table 2).

DISCUSSION

As basic research on the primary prevention of sports injuries, this study developed a quantitative motion analysis software specific to boxing to determine changes in the percentage of hits that landed on the participants.

In the FTS group, the percentage of hits that landed on the participants in overall fights was significantly lower post-intervention than pre-intervention. In contrast, the pre- and post-intervention comparison revealed no significant changes in the control group. Two factors were presumed for the low percentage of hits that landed in overall fights post-intervention with FTS. Based on the quantitative analysis of types of hits that landed, combinations that increased the likelihood of a successful hit, and whether various types of hits were likely to land when a certain defense was chosen, boxers adopted attention strategies based on motor imagery by reflecting upon numerical values and videos. In addition, the analytical data facilitated training so that boxers could efficiently improve their defensive techniques before their next fight. The context for these factors can be found in a study by Sakamoto et al.[9] wherein they examined a combination of observation and imagery of an action. Sakamoto et al. reported that the combination of observation and imagery enhanced the corticospinal tract excitability more than either approach alone. In addition, Sakurada et al.[10] reported that appropriate attention strategies based on an individual's ability to perform motor imagery improve performance in a motor learning task. This study did not include

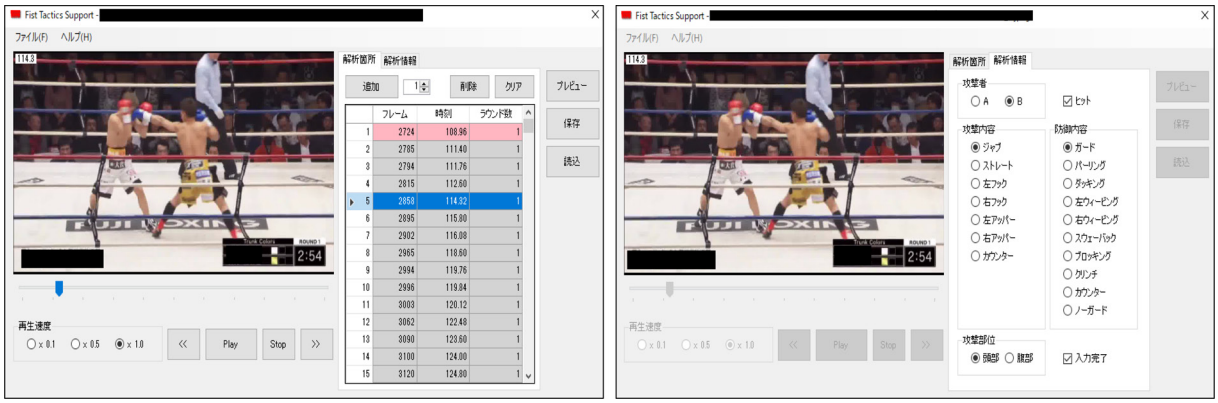

Fig. 1. Analysis scene by FTS*.
*FTS is a software designed to quantitatively analyze athletic performance by importing match video into the software, setting analysis points according to the time axis, and inputting the type of attack, type of defense, part of the attack, and whether or not a hit was made.

Table 1. Match interval and number of rounds

Group	Match interval (months)	Number of rounds
FTS	3.4 ± 0.6	5.2 ± 2.1
Control	3.6 ± 0.7	5.3 ± 1.8

FTS: Fist Tactics Support.
n=24, Mean ± Standard deviation.

Table 2. Changes in the percentage of hits that landed with FTS use

Group	Pre-intervention	Post-intervention
FTS	35.8 ± 5.9	27.1 ± 4.6*
Control	34.6 ± 7.2	35.6 ± 9.4

FTS: Fist Tactics Support.
Pre-intervention: before FTS use; Post-intervention: after FTS use.
n=24, units (%).
Mean ± Standard deviation *p<0.05.

items to assess motor imagery; therefore, these changes cannot be assessed from a neurophysiological perspective. However, boxers and trainers can rationally analyze fights retrospectively and receive feedback from their fight videos, analyzed data, and analysts; therefore, corticospinal excitability may have been enhanced and motor-related areas such as the supplementary motor cortex may have been activated during feedback. Thus, we believe that FTS helped the FTS group with motor imagery of the trajectory of hits that landed, types of attacks, and selection of a corresponding defense. This was efficiently reflected in the understanding and devising of tailor-made responses based on FTS analysis. In other words, the result that fewer hits that landed on the particpants in the FTS group after the intervention means that their defensive posture, which makes them more vulnerable to being hit, was improved, which may have had a positive impact on their performance in the match.

This study used an index, the percentage of hits that landed on the particpants in overall fights, to explore the possibility of the primary prevention of boxing injuries. Boxing is a sport with attacks limited to the head and abdomen; therefore, brain injuries are far more common than those in other sports[11, 12]. Lowering the percentage of hits landing on the head is directly linked to a reduced risk of brain injury. Moreover, lowering the percentage of hits that land is also likely to reduce the risk of being “punch drunk”; this is crucial in protecting a boxer’s life and allowing boxers to live normally after retirement.

A limitation of this study is that it may be affected by the participant’s years in the boxing, the interval between match, and the number of rounds performed. In the future, a neurophysiological assessment should be added to the system when providing feedback using FTS, and the effectiveness of FTS as an intervention should be verified from various perspectives, including gender differences, age, and years in the sport.

Funding and Conflicts of interest

The authors state to have no conflicts of interest regarding this paper.

ACKNOWLEDGMENT

The authors would like to thank all boxers and relevant individuals who cooperated with this study.

REFERENCES

1) Bledsoe GH, Li G, Levy F: Injury risk in professional boxing. South Med J, 2005, 98: 994–998. [Medline] [CrossRef]
2) Zazryn TR, Finch CF, McCrory P: A 16 year study of injuries to professional boxers in the state of Victoria, Australia. Br J Sports Med, 2003, 37: 321–324. [Medline] [CrossRef]
3) Zazryn T, Cameron P, McCrory P: A prospective cohort study of injury in amateur and professional boxing. Br J Sports Med, 2006, 40: 670–674. [Medline] [CrossRef]
4) Butler RJ, Butler MS: Neuropsychological investigation of amateur boxers. Br J Sports Med, 1994, 28: 187–190. [Medline] [CrossRef]
5) Tani S, Ohashi G, Otsuki J, et al.: A study on the incidence of acute subdural hematoma in professional boxing: based on statistics from the past 23 years. J Jpn Soc Clin Sports Med, 2002, 10: 310–313.
6) Izumi S, Kaneoka K, Miyamoto T, et al.: A study on injuries to amateur boxers. J Jpn Soc Clin Sports Med, 2009, 17: 225–231.
7) Sekino H, Hattori M, Katayama Y, et al.: Acute brain injury in Japanese amateur boxing: based on a survey. J Jpn Soc Clin Sports Med, 1996, 13: 227–231.
8) Tani S, Ohashi G, Otsuki J, et al.: The effects of punches in professional boxing: based on a nationwide survey. J Jpn Soc Clin Sports Med, 2001, 9: 413–416.
9) Sakamoto M, Muraoka T, Mizuguchi N, et al.: Combining observation and imagery of an action enhances human corticospinal excitability. Neurosci Res, 2009, 65: 23–27. [Medline] [CrossRef]
10) Sakurada T, Hirai M, Watanabe E: Optimization of a motor learning attention-directing strategy based on an individual's motor imagery ability. Exp Brain Res, 2016, 234: 301–311. [Medline] [CrossRef]
11) Moseley IF: The neuroimaging evidence for chronic brain damage due to boxing. Neuroradiology, 2000, 42: 1–8. [Medline] [CrossRef]
12) Constantoyannis C, Partheni M: Fatal head injury from boxing: a case report from Greece. Br J Sports Med, 2004, 38: 78–79. [Medline] [CrossRef]