ANALYZING SELF-ASSESSMENT OF PUNCHING INTENSITY BETWEEN EXPERIENCED AND INEXPERIENCED BOXING ATHELETES

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Due to the direct confrontation with a training or sparring partner, boxing and other martial arts represent a unique situation and the importance of accurate self-assessment, in which an incorrect self-assessment can lead to severe injuries for the participant himself or the sparring partner. The study aimed to investigate the self-assessment accuracy and repeatability between 26 experienced and inexperienced athletes for pre-defined punching intensities using a developed boxing monitoring sensor system. The results show considerable overestimated self-assessed punching intensities in the inexperienced in contrast to the experienced group revealing a substantial deficiency of punching intensity self-assessment.

KEYWORDS: martial arts, instrumented boxing glove, punching intensity.

INTRODUCTION: Athletes' performance during training and sports events evokes situations determined by self-assessment and evaluation by third parties (Blecharz, 2014). The self-assessment is influenced and regulated by situation-dependent emotional and cognitive factors (Howle, 2013). The individual self-perception in martial arts training and competition, research in psychology and pedagogy describe the individual ability of self-assessment scenario in close connection with aggressive reactions to the environment and the ability to control aggressive impulses or to manifest the resulting energy in a socially acceptable way (Cynarski, 2006). Due to the direct confrontation with a training or competition partner, boxing and other martial arts represent a unique situation and the importance of accurate self-assessment, in which an incorrect self-assessment can lead to injuries of the participant himself or the training partner (Kontos, 2004; Saw, 2017). Studies dealing with self-assessment of athletes predominantly have their origins in the field of psychology and pedagogics. Questionnaires such as the *Athlete Self-Report Measure* (ASRM) [21] are primarily utilized as self-assessment techniques in athletes. After extensive literature research, no methodological approaches were found in martial arts and combat sports disciplines that report an objective self-assessment of athletic punch intensity based on quantitative data acquired by measurement devices.

This circumstance is growing in importance since boxing classes with self-determined reduced punching intensity are widely used in fitness boxing or its interdisciplinary implementation in school sports, as well as in social institutions where it is used, i. a. in therapeutic youth facilities for the prevention of violence and self-control (Marquardt, 2013; Mösch, 2015). However, it is questionable to what extent participants can objectively and accurately assess their punching intensity to avoid injuring the training partner or unintentionally violating the rules of an event.

On this occasion, the possibilities of smart wearables can be considered in a broader context, namely, to provide an additional tool for athletes and trainers. With the help of direct biofeedback, coaches and athletes can objectively and accurately evaluate punch intensities in training and competition.

Hence, the presented study aimed to investigate athletes' self-assessed punching intensity after performing boxing-specific punching techniques using an instrumented boxing glove. As the literature argues that a realistic and accurate self-evaluation is only possible from a higher experience level in the respective combat sport that is close to excellence (MacNamara, 2011) a group of experienced boxing athletes was compared to a group of inexperienced athletes. It was hypothesized that there is a significant difference between experienced and inexperienced boxers in terms of the accuracy in self-assessed punching intensities of 50% and 70% within the investigated boxing technique.

METHODS: A total of 26 male participants took part in the study. The experienced athlete group consisted of 9 participants (mean ± SD; age: 26.3 ± 4.5 years, height: 1.78. ± 6.5 m, mass: 79.43 ± 9.3 kg, experience: 7.4 ± 3.3 years). The inexperienced athlete group consisted of 17 participants (mean ± SD; age: 21.7 ± 2.5 years, height: 1.79 ± 9.8 m, mass 75.92 ± 8.2 kg, experience 0.4 ± 0.4 years). The separation between experienced and inexperienced athletes was conducted according to Lenetsky et al. (2019).
The experimental protocol used in this study consisted of the three most common punching techniques in boxing (Thomson, 2016) to be tested in random order (jab, cross, hook). The participants were instructed to start the respective boxing techniques with 100% of their self-assessed punching intensity followed by 50% or 70% self-assessed punching intensity, respectively, in a randomized order. Each self-assessed condition within the individual boxing technique was repeated 5 times against a stationary 40 kg punching bag (Paffen Sport GmbH & 134 Co. KG, DE), starting from a static defensive position.
The kinetic data was acquired at 1000 Hz with a custom-developed and validated boxing monitoring system for in-field applications (Menzel, 2021). The boxing monitoring system was incorporated into an AIBA-certified boxing glove (0.340 kg, 12 ounces) from Adidas (Adidas AG, DE) without significantly modifying the physical properties of the sports equipment. Based on the piezoresistive principle, the force-sensing resistors covered an area of 106 × 106 mm of the glove's punching region.
The buffered data collected during the experimental performance of the punching tests were processed and analyzed using MATLAB (2018b) routines (The MathWorks, USA). Raw data were filtered using a finite impulse response lowpass filter. The mean peak-force magnitudes (in N) derived from the 5 repetitions corresponding to the self-assessed 50, 70 and 100% punching intensity in each boxing technique were used for the data analysis.
The statistical analysis was performed using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corporation, USA). Descriptive data are presented as group mean-percentage deviations between the self-assessed punching intensities (50% and 70%) and percentage values derived from the measured peak-force values. Normal distribution was examined using the Shapiro-Wilk test. The Levene test was performed to check for homogeneity in the variance of the experimental data. The independent Student's t-test was used to analyze variation in the test performance between experienced and inexperienced participants. In the case of a lack of variance inhomogeneity, Welch's test was used to analyze variation. For all statistics, a 95% confidence interval was calculated with an alpha level set as $p = 0.05$ to detect statistically significant differences. The effect size was determined by using Pearson's product-moment coefficient r. According to Cohen (Cohen, 1988) the effect size r was classified: 0.1 = small; 0.3 = medium; 0.5 = large.

RESULTS: *Cross punch:* The evaluation of the experimental data on the self-estimated for the 50% impact intensity shows that the group of experienced test persons performed the cross punches with a mean deviation of 3.57% (SD = 3.38%) based on the test instructions. The inexperienced group of participants shows a greater deviation of 29.9% with a standard deviation of 16.39% of their self-estimated executed impact force. The mean difference between the experienced and inexperienced group of participants concerning their self-estimated punch intensity exhibits a difference of -26.32% (95% - CI [34.76, -17.89], $p = 0.001$). The calculated effect size indicates a strong effect of 0.8. The analysis of the 70% impact intensity revealed that the group of inexperienced athletes showed a mean deviation of 21.76% (SD = 17.58%) from the specified and individually determined impact force. In comparison, the experienced group performed the requested 70% intensity level with a mean deviation of 5.35% (SD = 3.9%). The mean accuracy of the self-assessed punching intensities was 16.41% more accurate in the expert group (95% - CI [-25.51, -7.31], $p=0.001$), showing a large effect of 0.61 between the two groups.
Hook punch: The participant group of inexperienced participants executed the self-assessed hook punch with a mean of 26.93% (SD = 43.28) above the requested punch intensity of 50%. In contrast, the experienced participants showed a self-estimated impact intensity with a deviation of 6.28% (SD = 6.23) from the requested intensity of 50%. This represents a group-

specific deviation of the self-estimated accuracy with a mean of -20.65% (95% - CI [-41.89, 0.58], p = 0.056). The Pearson product-moment coefficient r exhibited a small effect size of 0.16. The group of experienced participants revealed a mean deviation for the punching intensity of -8.71% and a standard deviation of 7.76% considering the 70% self-estimated impact intensity condition. In contrast to the previous conditions, the inexperienced participants performed the hook punching technique with a mean deviation of -0.71% (SD = 28.12) of the 70 % intended intensity (Figure 1e). This corresponds to a mean difference of -8% (95% - CI [-22.50, -6.5], p = 0.27). The effect size of 0.08 outlines a negligible effect.

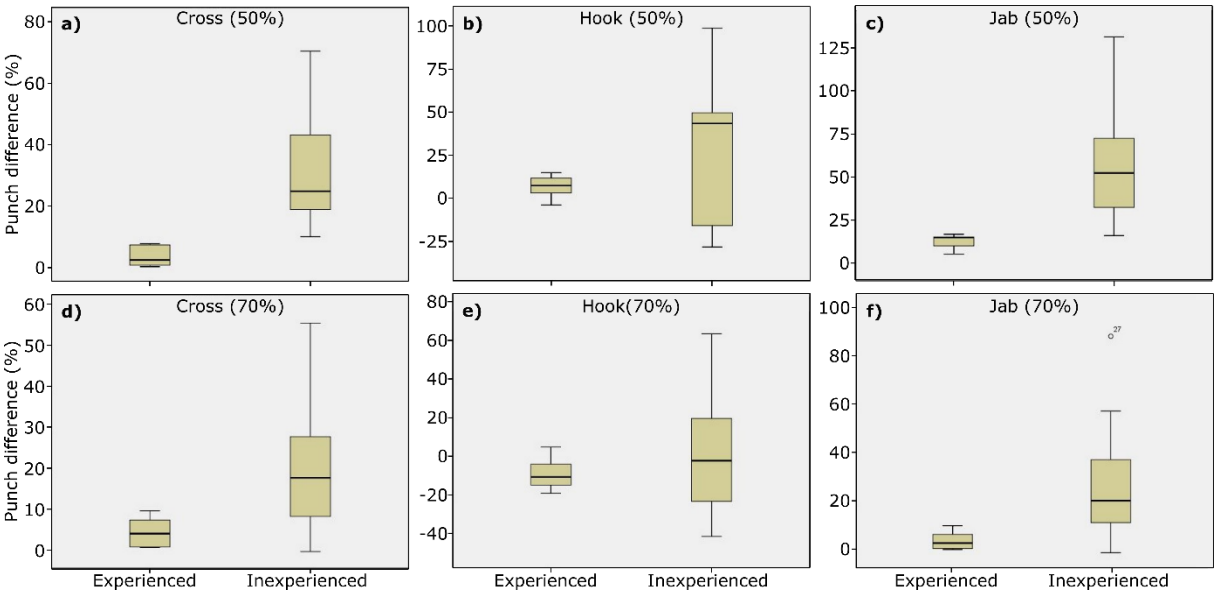

Figure 1: Boxplots illustrating the accuracy of self-assessment punching intensity (50%, 70%) for the four investigated boxing techniques comparing experienced vs. inexperienced participants.

Jab punch: The results of the inexperienced participants revealed a mean deviation of 58.35% from the specified impact intensity of 50%, with a standard deviation of 29.91%. This outcome leads to a group difference of -43.24% between the experience and inexperienced participants (95% - C [-57.88, -28.6], p = 0.001). The effect size of 0.94 clarifies a meaningful difference between the two tested groups. The self-estimated 70% punching intensity analysis demonstrates that lesser experienced boxing group conducted the punches with a mean deviation of 26.74% (SD = 22.86%) from the demanded punch level. In comparison, the experienced group showed a mean deviation of 5.42% (SD = 3.56%), resulting in a mean deviation of -21.32% (95% - C [-32.57, -10.06], p = 0.001). The effect size of 0.61 indicates a considerable difference between the tested groups.

DISCUSSION: The examination of self-assessment of the individual's physical performance in the field of sports is an essential criterion in the adaptation to existing guidelines and regulations as well as for the optimization of motion and technical processes (Johnson, 2011; Saw, 2017). Considering this assumption, the outcomes of the current study underline the combination of, i. a., technical, strength, coordination and punching velocity-related deficits in a group of inexperienced boxers compared to experienced boxers reflected by considerably inferior self-assessed punching intensities in the inexperienced group deviating from the demanded intensity levels. Apart from the unexpected result concerning the hook punches (70% assessment condition), the inexperienced group generally presented overestimated self-assessed punching intensities, a widespread human psychological phenomenon according to the phenomenon described by Johnson & Levine (2009). The results demonstrate the difficulty in the accuracy with that inexperienced boxing athletes can control and assess their punching intensity and the strong deviation from the actual default punch level. According to Marquard (2013), this is the basic requirement, as punches are classified differently from participant to participant and therefore, a good self-assessment of the impact severity is of fundamental

importance. The significantly greater variance in the inexperienced group illustrated in Figure 1 also clarifies the poor reproducibility of the impact intensities, with reproducibility as a fundamental requirement in boxing.
The current study's outcomes exhibit the needs and the possibilities to provide valuable and unique information to sports and science practitioners that can be collected and evaluated by using smart sports equipment such as the developed boxing monitoring system. For this reason, the study provides a new field of application for smart wearable devices in martial arts and combat sports by analyzing the self-assessment of athletes. Since all punches were executed in a controlled manner against a stationary punching bag, it would be of great interest to measure the frequencies of the different punch intensities during a sparring match or a real competition to determine the intensity of the strokes that are performed more frequently and less technically controlled during the competition.

CONCLUSION: The current investigation highlights that an accurate assessment of inexperienced boxing athletes regarding their stroke intensity is impossible without a significant deviation from the intended intensity. On the other hand, experienced athletes with an experience level of approx. seven years reveal the capability of adequate self-assessment accuracy and repeatability. The presented monitoring sensor system can be an important supportive tool for providing direct and objective feedback in various martial arts-related scenarios. Additionally, the use of load-quantifying devices on a regular basis during training and competitions can significantly contribute to reducing the risk of brain injuries. This approach is common practice in a few head-impacted related sports disciplines but has not yet been introduced broadly in combat sports.

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