Effects of using rigid tape with bandaging techniques on wrist joint motion during boxing shots in elite male athletes

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Effects of using rigid tape with bandaging techniques on wrist joint motion during boxing shots in elite male athletes

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A R T I C L E I N F O

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A B S T R A C T

Objectives: To investigate the effects of bandaging techniques on wrist motion on impact during different shot types in elite male boxers.
Design: Repeated-measures study.
Setting: Field Experiment
Participants: Two shot types, straight and bent arm, were assessed with 18 elite male boxers wearing either bandage only or bandage plus tape.
Main Outcomes Measures: Wrist motions and time to peak wrist angles, on impact, were measured with an electromagnetic tracking system.
Results: Wrist motion on impact occurred concurrently in flexion and ulnar deviation for both shot types. For both motions, significant ($p < 0.001$) effects for bandaging techniques ($\eta^2 = 0.580–0.729$) and shot types ($\eta^2 = 0.165–0.280$) were observed. For straight and bent arm shots, wrist motion on impact occurred within 50% and 40% respectively of total active wrist motion for bandage only compared to within 20% and 15% for bandage plus tape. Time to peak wrist angle on impact increased significantly ($p < 0.001$) for both shot types when adding tape to bandage.
Conclusions: Adding tape provided an additional 25–30% reduction in wrist motion compared to bandage only, with a 1.2–1.4 increase in time to peak wrist angle, on impact for both shot types. This information could assist various individuals and organisations towards better hand-wrist protection.

1. Introduction

Boxing is one of the most ancient of all recorded sports, with evidence of hand-wrist bandaging since c. 1600 BCE (Gems, 2014, pp. 1–8). Bandaging techniques, to protect the hand-wrist from injuries, have evolved with regulations in place on what boxers can use during competition (BBBofC, 2022; Gems, 2014, pp. 1–8; IBA, 2022a). Some bandaging techniques only specify the use of cotton material (IBA, 2022a). Other techniques include rigid tape (IBA, 2022a; BBBofC, 2022), which is often used in sports as prophylaxis or post-injury management aiming to improve support and stability at joints (Kim, Weon, Kim, Koh, & Jung, 2020; Purcell et al., 2009; Sato et al., 2019). To date, no study has quantified how bandaging techniques influence wrist motion on impact in boxing.

Boxers are instructed to make a fist before impact, which appears valuable to create stability at the wrist (Salva-Coll et al., 2011). When a shot is thrown correctly, the index and middle finger knuckles display the largest proportion of impact forces, explaining why carpometacarpal injuries at the index and middle finger are more common than at the other fingers (Loosemore, Lightfoot, Meswania, & Beardsley, 2015, 2017; Melone et al., 2009). Concomitant avulsion of the tendons attaching at the base of the index and middle metacarpal joints, Extensor Carpi Radialis Longus and Brevis respectively, are also identified from clinical practice (Gatt, 2022; Najefi et al., 2016; Nazarian et al., 2014; Mundell et al., 2014). Extensor Carpi Radialis Longus and Brevis muscles are typically described to perform combined extension and radial deviation of the wrist (Tanrikulu et al., 2014), the opposing action of ulnoflexion motion. Reducing the amount of ulnoflexion, identified as occurring on impact in boxing (Gatt et al., 2021), would appear important for injury risk reduction.

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Injuries to the hand-wrist account for 16–35% of all boxing injuries in training and competition, with carpometacarpal instability of the hand incurring the highest time loss from training (Loosemore, Lightfoot, Palmer-Green, et al., 2015, 2017). Loosemore et al. (2017) observed a higher rate of hand-wrist injuries, calculated per 1000 h of participation, in competition (347 injuries) than in training (<0.0.5 injuries). The competition formats in these studies utilised bandaging only techniques (i.e. no tape). When rigid taping was introduced, to a professional boxing style bandaging technique in some Olympic style competition formats, fewer carpometacarpal injuries were observed than other formats which allowed bandaging only (Gatt, 2022). Fewer wrist injuries were also observed in training when adding tape to bandaging as a standardised approach (Gatt, 2022). The effect of adding tape to bandaging, on wrist motion on impact, is however unknown. Considering tape is widely known to be adhesive with high tensile stiffness, we expect that applying it to bandaging to better support and limit wrist motion on impact, which may then reduce injury risk.

To date, only one study assessed wrist motion on impact in boxing, although standard bandaging was applied the effect of technique was not considered (Gatt et al., 2021). Flexion occurred concurrently (achieving peak angle on impact at the same time) with ulnar deviation for both straight and bent arm shots, with both motions greater in straight than bent arm shots (Gatt et al., 2021). We therefore hypothesised that; a) less wrist angular motion on impact occurs with tape added to a traditional bandage technique for both straight and bent arm shots, and b) more wrist motion on impact occurs in straight than bent arm shots for both bandage only and bandage plus tape. Further, we aimed to identify; i) if time to peak angle on impact is altered when adding tape, and ii) the effect of taping on reducing wrist motion during quasi-static testing, allowing for a comparison of wrist motion during the impact testing, whilst providing a reference of total wrist range of motion without any bandaging.

2. Method

2.1. Participants

Participants (18 elite male boxers), with no upper extremity symptoms and no hand or wrist injuries within the last three months, were recruited from the Great Britain National Squad, ranked 3rd in Olympic boxing (IBA, 2022b; Athlete365Boxing, 2021). Characteristics (mean ± standard deviation) were as follows: age 23 ± 2 years (range: 19–27 years), stature 177 ± 11 cm (range: 156–195 cm), and mass 71 ± 17 kg (range: 50–114 kg). All participants were right-arm dominant and orthodox stance boxers (left-hand leading).

2.2. Instrumentation

To measure wrist motion on impact, the same equipment as previous studies was used, showing good accuracy and reliability (Gatt et al., 2019, 2021). An electromagnetic tracking system (Polhemus Liberty™ 240/16, Colchester, VT, USA), with 6-degree-of-freedom (DoF) position and orientation receivers, was used to record kinematic data at the maximum available sampling rate of 240 Hz. During pilot testing, metal distortion was investigated with both static and dynamic testing, with no distortion identified. Further, we assessed distance and time of punches thrown, using the same equipment, to estimate the average speed of both shots and further account for effects on wrist motion.

2.3. Protocol

Electromagnetic receivers (× 3) were fixed to the left upper limb (hand, forearm, and arm) of participants (Fig. 1), as done previously (Gatt et al., 2019, 2021). Two bandaging techniques were used in this study for both impact and quasi-static testing (Figs. 1 and 2). Bandage only; a standard bandaging technique (supplementary materials) using a commercially available (Adidas®) 4.5-m-long cotton bandage. Bandage plus tape; a standardised technique (supplementary materials) using 2.5 cm width rigid (zinc oxide) tape, added to the bandage only technique. All bandaging was applied by the lead author, a physiotherapist with extensive experience in hand-wrist bandaging boxers in both training and competition. For all impact conditions a boxing glove (14 oz Adidas), of the correct size, was worn by each participant covering the hand and forearm receivers (Fig. 1c & d).

2.4. Quasi-static testing

Before the impact testing, wrist motion was measured without bandaging, and for both bandaging conditions, using the same equipment and technique as prior studies (Gatt et al., 2019, 2021). The quasi-static testing allowed wrist range of motion (ROM) on impact, during the impact testing, to be quantified as a percentage of both the available active wrist ROM occurring with both bandaging techniques (aROM), and the total wrist active ROM occurring with no bandaging (tROM).

2.5. Impact testing

The target was a hanging boxing bag (Rival heavy bag 91 kg, L: 152 cm × W: 48 cm × D: 0.6 cm) located in the Great Britain boxing gym (Fig. 1d). Following a similar methodology to Gatt et al. (2021), only lead arm shots were chosen. Lead bent arm shots exhibit greater peak fist speed and lead straight arm shots display the shortest delivery time (Stanley et al., 2018), making the choice of shots relevant to the methodology of this study. Boxers were instructed to throw straight and bent arm shots with their lead arm at submaximal intensity, reflective of their normal training behaviour. On the other hand, it could be expected that injuries occur at maximal effort, combined with terminal range of motion. Submaximal shots were chosen for this study to limit the risk of injury to participants.

Shots were performed six times, allowing a between-shot break of approximately 3 s. The 2nd to 5th shots were used for statistical analysis, calculating the mean of trial peaks (Dos'Santos et al., 2020), a method shown to have good reliability when assessing wrist motion on impact in boxing (Gatt et al., 2019). The 1st and 6th shots were not analysed, to limit potential errors/inconsistencies from those thrown at the start and end of testing (Gatt et al., 2019). Boxers performed both shot types in both bandaging conditions in the same session. Both order of bandaging techniques and shot types thrown were randomly assigned

2.6. Data processing & definitions for peak wrist angle, time to peak for wrist angle, and average speed of shot

The tracking system data from all testing procedures were processed using Visual 3D v3.79 (C-Motion, Germantown, MD, USA). Following a similar protocol to previous studies, marker trajectories were filtered using a low-pass fourth-order zero-lag Butterworth filter in Visual 3D with a 10 Hz cut-off frequency (Gatt et al., 2019, 2021). Body-fixed reference frames were then constructed using the positions of anatomical landmarks located with the digital stylus during a static calibration trial; Hand,

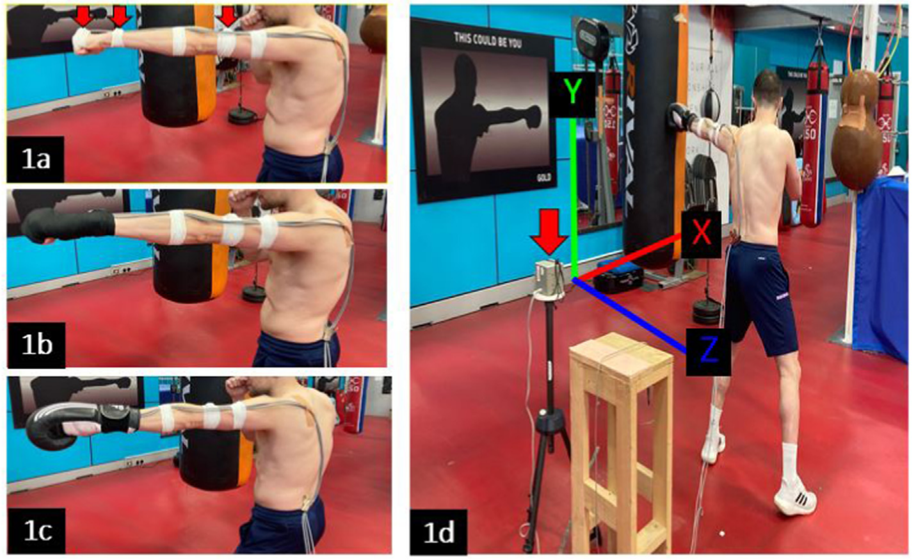

Fig. 1. Electromagnetic tracking system receiver placement; a) on the hand and forearm using rigid tape and cohesive bandaging to secure the sensors, with arrows above the arm indicating their position, b) with a standard bandage technique covering the receivers, c) with a boxing glove covering either bandage only or bandage plus tape techniques and receivers, and d) during impact testing on the bag in the boxing gym with an arrow above the source box, and with xyz coordinate system indicating the position of the participant relative to the source box.

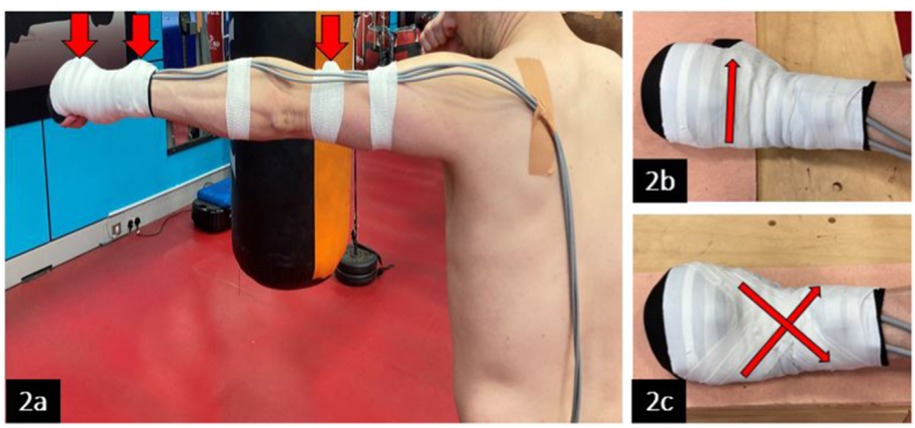

Fig. 2. Electromagnetic tracking system receiver placement: a) on the hand and forearm for the quasistatic and shot testing with addition of a standardised taping technique to the bandaging technique, b) showing a continuous circular strip of tape starting distally and finishing proximally at the hand and wrist, and c) showing the addition of six strips of tape (three criss-cross) to the circular tape. The arrows in b) and c) indicate the direction the tape was applied.

Forearm and Arm, as defined before (Gatt et al., 2019, 2021). Segment coordinate systems were embedded in the left upper limb segments, defined based on the location of the anatomical markers such that the x-, y- and z-axis were medio-lateral, anterio-posterior and longitudinal, respectively. The filtered trajectories of the digital markers were used to compute the orientation of the distal segment relative to the proximal one using Cardan angles (xyz rotation sequence) (Gatt et al., 2019, 2021; Grood & Suntay, 1983). Positive and negative rotations around the x-axis were defined as flexion and extension, respectively, and positive and negative rotations around the y-axis were defined as radial and ulnar deviation, respectively.

Peak wrist angle on impact with the bag was identified using a previously defined manual method (Gatt et al., 2019). This method consisted of i) visual observation of the virtual upper limb to identify the point of hand impact observed at terminal elbow extension for straight arm shots or terminal shoulder horizontal adduction for bent arm shots, ii) movement at the x-axis and y-axis aligned together with distance observed to occur simultaneously at the perceived point of hand impact, and iii) movement at the x-axis aligned with acceleration of the wrist with the maximum acceleration observed to occur simultaneously with maximum x-axis distance. Further we identified the time to peak angle for each shot.

Average speed of shot was calculated using the equation:

$$S = \frac{d_{PI} - d_{SS}}{t_{PI} - t_{SS}}$$

Key moments were s (average speed of shot), d (distance), t (time), PI (point of impact of the hand on the boxing bag), SS (point the hand started moving towards the boxing bag). Distance and time from SS to PI were identified using a manual method (Figs. 3 and 4) consisting of; i) visual observation of the virtual upper limb to identify movement along the path of either the z-axis or x-axis respectively for straight arm and bent arm shots, and ii) identify the point of hand impact observed at pre-terminal elbow

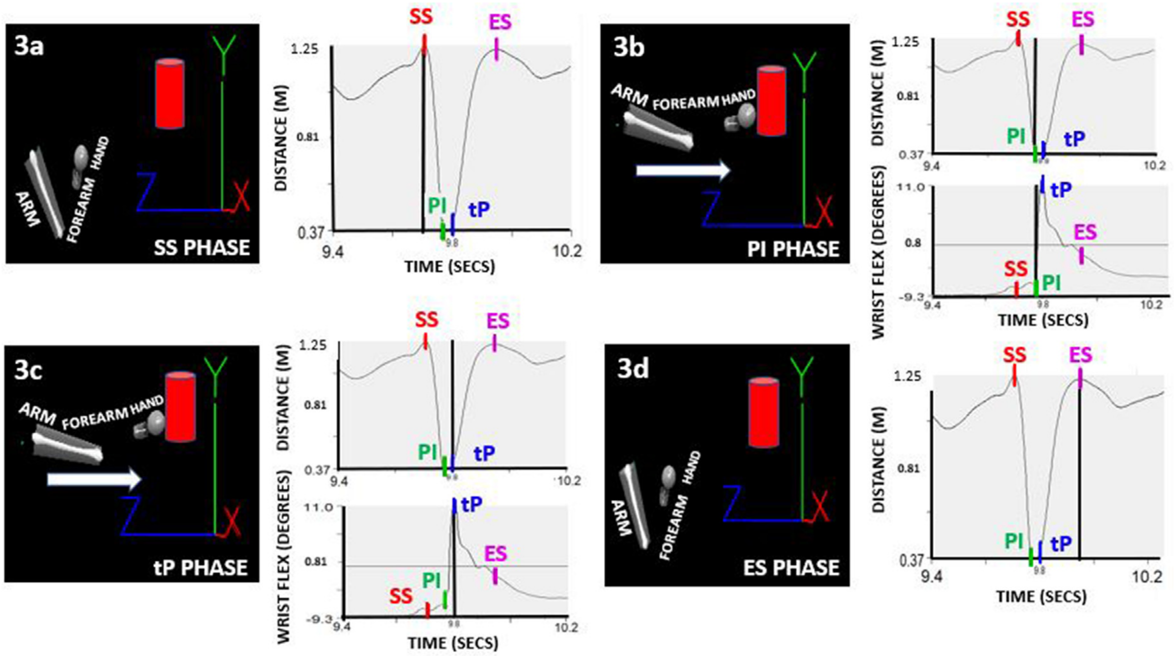

Fig. 3. Visual 3D software for the straight arm shot; on the left, computer generated model showing individual anatomical segments; arm, forearm, hand. A target (red circle) is included to indicate the location of the bag equipment. An arrow indicates the direction of upper limb movement. On the right the path of the upper limb (using the hand segment relative to the source box) along the z-axis with event markers created to identify the sequence of shots; point when the hand begins to move in the direction of the target (SS), point of impact of the hand with the boxing bag (PI), time to peak wrist angle on impact (tP), point when the hand returns to the starting position or shot ends (ES). At both PI and tP phases wrist flexion-extension (x-axis) is included to show corresponding wrist motion on impact with boxing upper limb phases. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

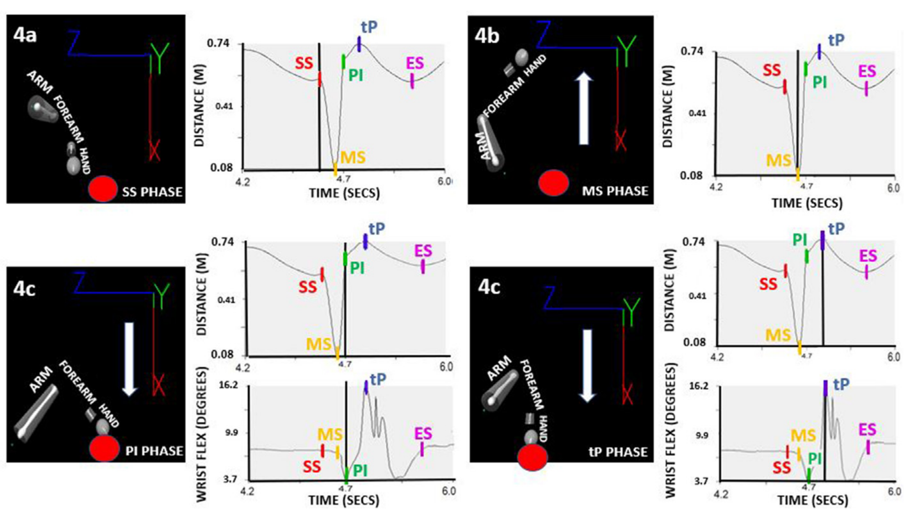

Fig. 4. Visual 3D software for the bent arm shot; on the left, computer generated model showing individual anatomical segments; arm, forearm, hand. A target (red cylinder) is included to indicate the location of the bag equipment. An arrow indicates the direction of upper limb movement. On the right the path of the upper limb (using the hand segment relative to the source box) along the x-axis with event markers created to identify the sequence of shots; point when the hand begins to move in the direction of the target (SS), mid-phase of shot showing the hand moving in the opposite direction of the target (MS), point of impact of the hand with the boxing bag (PI), time to peak wrist angle on impact (tP), point when the hand returns to the starting position or shot ends (ES). At both PI and tP phases wrist flexion-extension (x-axis) is included to show corresponding wrist motion on impact with boxing upper limb phases. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

extension for straight arm shots or pre-terminal shoulder horizontal adduction for bent arm shots, observed to occur prior to maximum x-axis wrist displacement. We further classified the stages of upper limb motion for both shots (Figs. 3 and 4).

2.7. Angle data analysis

The data from all testing procedures were analysed using a statistical spreadsheet (Jamovi v2.5.5, www.jamovi.org). Z-Scores for skewness and kurtosis were used to test for normal distribution of data with the threshold for the observed values set at ±2 standard deviations of the predicted values.

For both wrist angular motions, flexion and ulnar deviation, two-factor (2 × 2) repeated measures Analysis of Variance (ANOVA), with Tukey's test for post-hoc analysis (a = 0.05), were performed to assess the effect of banding techniques (bandage only and bandage plus tape) and shot types (bent and straight arm). Similar analysis was performed for time to reach peak angle and average speed of shot. Further, for all four wrist motions (flexion, extension, ulnar deviation, radial deviation) one-way ANOVAs, with Tukey's test for post-hoc analysis (a = 0.05), was performed to assess the effect of no bandaging and both bandaging techniques during quasistatic testing. All data are presented as means ± standard deviations. The magnitude of any differences (effect size) was assessed using Eta Squared (η^2) with the following benchmarks: *small* ($\eta^2 = 0.01$), *medium* ($\eta^2 = 0.06$), and *large* ($\eta^2 = 0.14$) (Lakens, 2013).

3. Results

3.1. Impact testing

All data for shot types were normally distributed with 95% of the observations falling inside the predicted Z-Scores.

3.1.1. Peak wrist angles

Wrist angular motions occurred concurrently in flexion and ulnar deviation for both shot types. A 2x2 ANOVA with Eta Squared revealed significant large effects for wrist motions of flexion and ulnar deviation, for both shot types and bandaging techniques (Fig. 5 & supplementary materials). A Tukey post-hoc comparison showed that both flexion and ulnar deviation motions differed significant ($p < 0.001$) for both shot types and bandaging techniques. Bandage plus tape reduced wrist motion compared to bandage only, and more motion occurred at the wrist with straight than bent arm shots (supplementary materials). For straight arm shots, all wrist angular motions on impact occurred within 50% of tROM for bandage only and 20% of tROM for bandage plus tape. For bent arm shots, all wrist motions on impact occurred within 40% of tROM for bandage only and 15% of tROM for bandage plus tape.

3.1.2. Time to peak wrist angles

A 2x2 ANOVA with Eta Squared revealed significant large effects for time to peak wrist angles for both shot types and bandaging techniques (Fig. 5 & Supplementary Materials). A Tukey post-hoc comparison showed that time to peak wrist angles differed significant ($p < 0.001$) for both shot types and bandaging techniques. Bandage plus tape increased time to peak wrist angles on impact compared to bandage only, with time to peak wrist angles on impact longer in bent than straight arm shots. Mean times to peak wrist angles for straight arm shots were 0.035 and 0.049 s respectively for bandaging only and bandaging plus tape, and for bent arm shots were 0.047 and 0.057 s respectively for bandaging only and bandaging plus tape (supplementary materials). The mean time to peak wrist angles on impact increased by 1.4 and 1.2 times for straight and bent arm shots respectively when adding tape to bandaging.

3.1.3. Average speed of shot

A 2x2 ANOVA with Eta Squared revealed significant large and small effects respectively for shot types and bandaging techniques for average speed of shot (Fig. 5 and supplementary materials). A Tukey post-hoc comparison showed that average speed of shot differed significant ($p < 0.001$) for both shot types and bandaging techniques. Average speed for straight arm shots were 7.2 and 7.7 m s^{-1} respectively for bandaging only and bandaging plus tape, and for bent arm shots were 9.1 and 9.6 m s^{-1} respectively for bandaging only and bandaging plus tape (supplementary materials).

3.2. Quasi-static testing

A one-way ANOVA with Eta Squared for bandaging techniques revealed significant large effects for all wrist motions, with the flexion showing the largest effect (Fig. 6 and supplementary materials). A Tukey post-hoc comparison showed significant differences between bandaging only and bandaging plus tape for flexion and ulnar deviation motions, but not for extension and radial deviation (Fig. 6).

4. Discussion

The effect of active ROM reduction by taping procedures has been shown at the wrist during activities of daily living (Mojaeva, 2021), and at the ankle during exercise and drop landing activities (Purcell et al., 2009; Sato et al., 2019). In boxing, although adding tape to bandage can constitute part of normal routine at some competitions, and sometimes during training, no study to

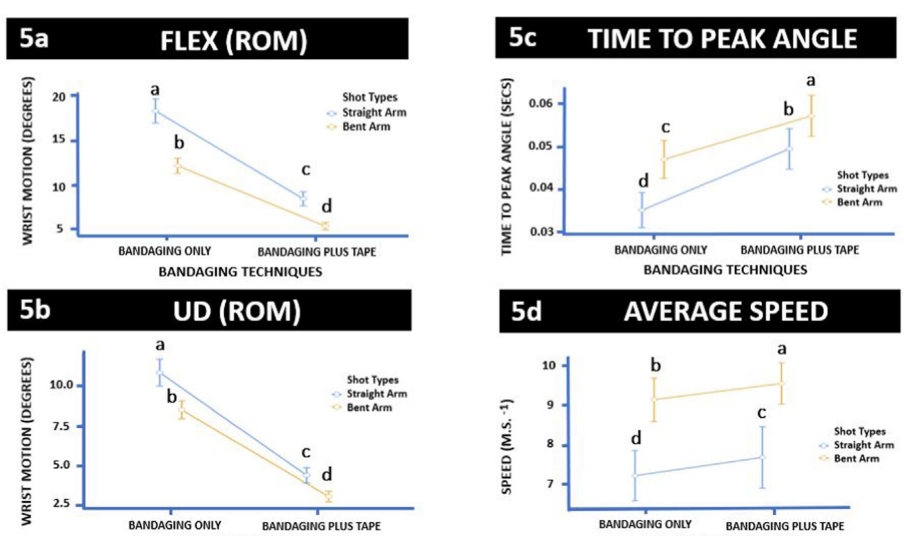

Fig. 5. The effect of bandaging techniques on; a) wrist flexion (FLEX) motion, b) wrist ulnar deviation (UD) motion, c) time to peak for wrist motion, d) average speed of shot. Error bars represent between-participants standard deviation.

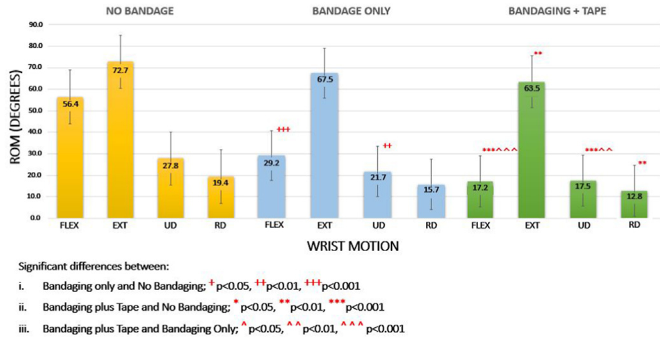

Fig. 6. The effect of bandaging techniques during the quasi-static testing on wrist ROM for Flexion (FLEX), extension (EXT), ulnar deviation (UD), radial deviation (RD). Error bars represent between-participants standard deviation. Significant differences indicated.

date has identified whether any difference exists as compared to bandage only. This study quantified wrist motion on impact in boxing using two bandaging techniques. Adding tape to the bandage provided an additional 25–30% reduction in wrist motion on impact compared to bandage only, for both straight and bent arm shots, confirming our primary hypothesis that less wrist motion on impact occurred when tape was added to a traditional bandage technique for both shot types.

Although it is assumed that taping might alter joint kinetics, no studies have been identified at the wrist. Sato et al. (2019) observed that ankle joint moments were significantly reduced when adding tape to an ankle during jump landing activities. Wrist guards used for snowboarding, which are a more rigid structure than tape, reduced peak force by at least 24% and increased time to peak angle by at least 1.8 times, when applied to a surrogate wrist in an impact test (Adams et al., 2021). Comparatively in our current study, adding tape to bandage during *in vivo* testing increased time to peak wrist angles by 1.2–1.4 times for both shot types. We did not investigate forces or joint moments. However, a reduction in joint moments might be expected when adding tape to bandaging, considering a decrease in wrist angular distance alongside an increase in time to peak wrist angles. Future studies should assess joint kinetics on impact, particularly as the role of hand-wrist protection has been considered in various activities and sports, using more rigid support (Burkhart & Andrews, 2010; Hwang et al., 2006; Michel et al., 2013), yet studies towards hand-wrist injury reduction are still lacking in boxing.

In the quasistatic testing, ulnoflexion motion was significantly reduced when adding tape to the bandage, agreeing with the results from the impact testing. However, no difference was observed in extension and radial deviation. In the quasistatic testing, all motions showed a significant difference between bandaging plus tape and no bandaging, as compared to bandaging only and no bandaging where only flexion and ulnar deviation motions were significantly reduced. The taping method utilised a circular followed by a cross-cross technique (Fig. 2 and supplementary materials). The circular technique is not widely considered, from clinical practice, to have a direction specific effect on reducing wrist ROM. This might explain the reduction observed in all motions in the quasistatic testing between bandaging plus tape and no bandaging. Conversely, the criss-cross technique was aimed at mainly reducing flexion and ulnar deviation, the motions occurring on impact as observed by Gatt et al. (2021). The significant reduction in flexion and ulnar deviation motions, when comparing bandaging plus tape and bandaging only, agrees with other studies where specific direction of taping limits the intended motion (Mojaeva, 2021; Purcell et al., 2009; Sato et al., 2019). We therefore recommend assessing the effect of bandaging techniques on reducing wrist motion using a quasistatic method, as this approach can be a quick method, especially when considering accessibility of widely used methods for measuring wrist motion (Surangsrirat et al., 2022).

Shot types also influenced the amount of wrist motion on impact. Wrist angles were greater in both flexion and ulnar deviation for straight than bent arm shots (Fig. 5). This finding confirms our second hypothesis that more wrist motion on impact occurs in straight than bent arm shots, for both bandaging techniques. This finding agrees with a previous study where bandage only was used (Gatt et al., 2021), whilst further showing the influence of shot types on wrist motion when adding tape. Average speed of shot was higher in bent arm (9.1–9.6 m s^{-1}) than straight arm (7.2–7.7 m s^{-1}) shots. Conversely, delivery times (SS to PI) were slower for bent arm (0.119–0.129 s) than straight arm (0.106–0.112 s) shots. This can be explained by the upper limb segment sequencing (Figs. 3 and 4), where a proximal-to-distal sequence between the elbow and wrist joints is not observed due to fixed elbow positions in bent arm shots (Stanley et al., 2018). During straight arm shots, the elbow joint straightens rapidly (Fig. 3) as it accelerates towards the target, via angular velocities generated at the shoulder joint (Cheraghi et al., 2014). Conversely during bent arm shots (Fig. 4), the elbow is fixed to an appropriate right angle whilst the shoulder exhibits a large amplitude of motion (Piorkowski et al., 2011). As more wrist motion occurs in straight than bent arm shots, whilst higher velocities occur in bent than straight arm shots (Dinu et al., 2020; Piorkowski et al., 2011; Whiting et al., 1988), we need to consider other factors effecting wrist motion. Further, as more wrist injuries are typically observed with straight arm shots (Gatt, 2022), the greater effect of taping on straight than bent arm shots further support the addition of tape to bandaging.

In this study, we observed changes in wrist motion, with both bandaging techniques, which could not solely be accounted by passive restriction. For flexion ROM, adding bandage during the quasistatic testing reduced wrist motion by 52% of tROM (i.e., aROM). In the impact testing, this motion was observed as 33% and 22% respectively of tROM for straight and bent arm shots. The difference in wrist motions observed between the impact and quasistatic testing conditions, is likely due to wrist active control (i.e., muscle function) rather than passive restriction (i.e., bandaging). When adding tape to the bandage, a difference was also observed between both testing conditions, for both shot types. Similar to bandage only, this difference could not be attributed solely to passive restrictions of bandage plus tape. However, with increased passive restriction, by adding tape to the bandage, a smaller difference was observed between the motion on impact and aROM compared to bandage only. Similar differences to flexion were also noted for ulnar deviation in both bandaging techniques. The potential implication is that less active control may be required, towards wrist stability on impact, with increased passive restriction (i.e., adding tape). Motion compensations can be challenging to understand, but they are clinically observed phenomena around joints and identified especially with pathologies (Bauman & Chang, 2013; Khandare et al., 2022). The effect of active stability at the wrist could be important in understanding the differences in wrist motion observed between straight and bent arm shots. Equally the effect of active vs passive stability could have a role towards understanding the mechanism of injuries in competitions where less support at the wrist is available, due to regulations limiting the type and amounts of materials, as compared to training.

We also observed other factors which are worth considering. The amount of wrist motion occurring on impact may be influenced by the level of boxing experience. For bandaging only, this study observed less than 50% and 40% of tROM for straight and bent arm shots respectively. This is greater than a previous study, using bandage only, which observed less than 30 and 20% of tROM for straight and bent arm shots respectively (Gatt et al., 2021). Participants in the current student were less experienced (<3 years on the Great Britain Squad) than participants in our previous study (>5 years on the Great Britain Squad). Dinu et al. (2020) observed more motion occurring at both the shoulder and trunk in less experienced boxers, when throwing both straight and bent arm shots. In their study, less experienced boxers were able to produce only about a third of the force produced by more experienced boxers, whilst the shot speed, although significantly lower, was closer (Dinu et al., 2020). Whether it is the ability to generate force, or specific technical aspects when throwing a punch, it appears that level of experience can influence the amount of motion occurring at different joints, which includes the wrist. Improving wrist support, especially for less experienced boxers, should therefore be a priority at both training and competition.

Although there was a significant effect ($\eta^2 = 0.365$, $p < 0.001$) in average speed between shot types, when adding tape to bandage the effect ($\eta^2 = 0.019$, $p < 0.001$) was too small to be considered meaningful. When adding tape to bandage, the average speed increased from a mean and standard deviation of 7.2 ± 1.2 to 7.7 ± 1.5 m s^{-1} in straight arm shots, and from 9.1 ± 1.1 to 9.6 ± 1.0 m s^{-1} in bent arm shots. Wearing tape has been shown to increase grip strength, however, the authors describe the effect as trivial and indicate a placebo (psychological) rather than a true physical effect (Mak et al., 2019). Whether the effect on punch speed observed in our study was a physical or placebo attribute, and could this effect increase in other training settings or competition, is beyond the scope of this paper. It is useful however, to consider whether having more support at the wrist enables more confidence towards throwing shots.

There are methodological limitations that should be acknowledged. The present study was performed solely on bags, which is one type of training method. Whilst a higher rate of hand-wrist injuries occurs in competition than training, a higher number of injuries at these regions are recorded in training than competition (Loosemore et al., 2017; Gatt, 2022). The type of injuries in both training and competition are similar, however lesser incidence of injuries at the carpometacarpal joints, which are influenced by wrist motion, have been recorded in training as compared to competition (Gatt, 2022). The main difference observed were the rules on bandaging at certain competitions, with fewer injuries incurred when rigid tape was allowed (Gatt, 2022). The amount of wrist motion recorded on bags in this study, compared to both training and competition at the point when injuries occur, could still differ. However, this study observed that wrist motion is significantly reduced on impact when adding tape to bandage compared to bandage only.

A wired electromagnetic tracking system was used to obtain wrist angular kinematics from sensors mounted directly on the skin, underneath the boxing glove. This required that data collection took place in a training rather than competition environment, which ensured there was no disturbance to the system's magnetic field due to the presence of ferrous metal (Roetenberg et al., 2007), and that the wires did not restrict participant movements during impact testing. Wireless systems might be useable in the future to enable collection in competitive environments, but they are currently too bulky to be safe and practicable, and they are still susceptible to distortion due to metal in the boxing ring.

Our approach to this study was aimed at controlling forces, although not objectively assessed with a device such as a punch dynamometer, (Diewald et al., 2022), by asking participants to throw shots at submaximal intensity levels. This approach was performed to improve ecological validity (Andrade, 2018), reflective of their normal training behaviour, and limit the risk of injury to participants. Most studies, however, typically consider a maximal intensity approach (Dinu et al., 2020; Kimm & Thiel, 2015; Whiting et al., 1988). Our results show that the average speed of the straight arm shot (7.2 ± 1.2 to 7.7 ± 1.5 m s^{-1}), thrown at submaximal effort, was within 89–95% of the average speed (8.1 ± 1.4 m s^{-1}) of another study where maximal effort was measured from beginning to end of shots thrown in the air (Kimm & Thiel, 2015). We are therefore confident the average speeds of the shots thrown by our participants to be as intended, submaximal (i.e., just below maximal intensity).

No blinding of the participants was performed towards their knowing which bandaging technique was used, which could have influenced their approach towards punching. Blinding the participants to the type of bandaging technique is however questionable, as experienced boxers would feel the difference between the two techniques used in this study. We therefore acknowledge that although bias might be present, we aimed to reduce this by randomly assigning the order of shot types and bandaging techniques for participants. Further although no bandaging was used in one of the quasistatic testing conditions, this was not performed during the impact testing. Inserting a hand with no bandage into a glove would have displaced the sensors creating more error, as observed during piloting prior to Gatt et al. (2019). The bandage is also important to secure the electromagnetic sensors and reduce angle measurement error which can occur due to excessive skin movement. This is discussed in detail in Gatt et al. (2019).

Only males were included in this study as not enough elite female athletes were available to generate the numbers required, as calculated at priori. We therefore felt consistency with one sex was more appropriate for this study. Any wrist kinematic variations that might occur are due to bone size rather than sex differences (Rainbow et al., 2008), with hand speed in boxing observed to improve with experience regardless of sex or age (Kimm & Thiel, 2015). Future studies could however consider if any sex differences are present, to include potential specific interventions. Further, only the lead-arm was used for shots. We acknowledge that different shots in both the lead and back hand have distinct biomechanical differences (Stanley et al., 2018). How using different arms may affect the conclusions of this study is unknown, and future studies could consider kinematic variances at the wrist amongst all shot types in both lead and rear arm. Finally, the size of the gloves used in this study were 14oz, which are of the correct size and suitable for this study performed on training equipment. Since both 10oz and 12oz gloves are used in competition, wrist motion could potentially differ with these lighter, smaller gloves. Wrist motion might also differ between different models/brands of the same size of glove. Future studies could look at any changes in wrist motion when using different glove models and/or size.

5. Conclusion

This study showed the effect of bandaging techniques on wrist kinematics on impact when throwing straight and bent arm shots on a commonly used type of training equipment. Wrist angular motions occurred concurrently in flexion and ulnar deviation for both shot types. Adding tape to a traditional bandage technique provided an additional 25–30% reduction in wrist motion on impact compared to bandage only, with a 1.2–1.4 increase in time to peak for wrist angle, with a greater effect during straight than bent arm shots. This information could assist athletes, coaches, wider public and boxing associations in their decision making, with a consideration towards rule making, which can influence improved support of the hand-wrist region during punching activities.

Ethical statement

The following study was approved by the Sheffield Hallam University Research Ethics Committee (Ref No ER40698260). Prior to participation all subjects reviewed and signed informed consent.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2023.03.002.

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