The Takei Handheld Dynamometer: An Effective Clinical Outcome Measure Tool for Hand and Wrist Function in Boxing

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Abstract

Background: The aim of this article was to explore retrospectively the Takei dynamometer as a valid and reliable outcome measure tool for hand and wrist pathology in the Great Britain amateur boxing squad between 2010 and 2014. **Methods:** Longitudinal retrospective injury surveillance of the Great Britain boxing squad was performed from 2010 to 2014. The location, region affected, description, and duration of each injury were recorded by the team doctor and team physiotherapists. For each significant injury, we recorded hand grip scores using the Takei handheld dynamometer and compared the scores with baseline measures. **Results:** At the hand, fractures and dislocations were highly detected with an average difference of 40.2% ($P < .05$) when comparing postinjury to baseline measures. At the wrist, carpometacarpal and carpal joint injuries were highly detected with an average difference of 32.6% ($P < .05$). Other injuries provided varied results. In the absence of pathology, up to 15% difference between left and right scores can be considered normal with a predominance observed below 10%. A difference of 20% can be indicative of a form of pathology, although pathologies can also be present with lower difference or no apparent changes. A difference of $>20\%$ should be highly considered for significant pathology. **Conclusions:** The Takei dynamometer is a valid and reliable outcome measure tool for hand and wrist pathologies in boxing. Our study highlights the importance of appropriate clinical tools to guide injury management in this sport.

Keywords: boxing, hand, wrist, injuries, sport, handheld dynamometer, outcome measures

Introduction

Hand-wrist strength and function are essential components of daily living in both a sporting and nonsporting population. From throwing a dart to turning a door handle, the importance of hand-wrist function remains somewhat understated. The hand-wrist represents the most sophisticated tool in the human being, demanding a large amount from the nervous system in relation to its size.² The correlation of hand-wrist strength in the presence of disease and pathology is a wide and ever expanding area of research, with close links to malnutrition and arthritis.¹⁵

When evaluating hand-wrist strength and function, an understanding of the different grips is important especially in relation to the specific demands of various sports and activities. The 3 main prehensile patterns described are *power grip*, *pinch grip*, and *key grip*.⁹ Closing a hand with the thumb in opposition to all other fingers together generates a power grip.¹³ Pinch grip is generated by pressing the thumb pulp against the pulp of the index, middle, ring, and

little fingers' distal phalanges.¹⁶ Finally, key grip is achieved by pressing the thumb pulp against the lateral aspect of the proximal interphalangeal joint of the index finger.

Power grip measures a maximum voluntary force of the hand-wrist using a dynamometer.¹⁹ Two of the most commonly discussed dynamometers within the current literature are the Jamar and the Takei. The Jamar dynamometer is comprised of an adjustable anatomical rigid handle, hydraulic system, and analog display.¹ It has been found to be an accurate and reliable objective tool, being described by some authors as a *gold standard* for documenting manual grip strength.²¹ Conversely, when assessing the sensitivity

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Table 1. Review of Protocols Used for Handheld Dynamometers.

Authors	Protocol used
Watanabe et al ²⁰	Interval measurements with a 1-min rest period after each set (2 reps per set)
Amaral et al ¹	Three maximal isometric efforts held for 6 s with 2-min rest between reps
Ashford et al ³	Three reps per hand starting with the right, then left
Luna-Heredia et al ¹⁵	Three measurements made consecutively starting with right hand with 5-s rest between reps
Cadogan et al ⁵	Three maximal isometric contractions held for 6 to 7 s with 30-s rest between trials
Goodson et al ⁹	Best of three attempts recorded
Nayak ¹⁶	One maximal effort recorded per hand with 1-min rest between measurements
Fenter et al ⁷	Two test reps held for 2- to 4-s duration following 2 practice attempts; 2-min rest between trials

of this dynamometer in detecting submaximal grip effort on a healthy sample size, it was found that using current protocols allowed for patients to make deliberate weak efforts resulting in a false loss of grip strength.³ This indicates that when using and interpreting data, it is important to be fully aware of the targeted patients to reduce false-positive results from lack of intent. Similar to the Jamar, the Takei has also been found to be a valid and reliable tool to measure power grip.⁴ It uses an adjustable rectified and complacent handle shape, electromechanical system and a digital or analog display.

The literature surrounding these dynamometers indicates that they are both valid tools in measuring power grip,^{4,21} but the results cannot be directly compared. The best possible protocol to follow for all dynamometers remains inconsistent, but based on the results to date, it appears that certain criterion can be confidently chosen: 3 repetitions per hand, allowing the patient to perform without strict instructions, minimum of 2-s hold per repetition, and straight arm or bent arm. What has been highlighted by the current literature is that irrespective of the type of protocol chosen, using either the Jamar or Takei dynamometer, it is important to consistently maintain those criteria as any change will not allow a comparison with previous data (Table 1).

The objective of a boxer is to succeed in delivering a clean and correct punch to the opponent without getting punched in return.¹⁰ Strength in a boxer's upper and lower limbs is essential for victory and is seen as one of the keys to success.⁶ The position of the hand in a glove is maintained in a closed fist. The boxers tend to have a relatively loose fist, and like in most other combat sports, a fist is made before prior impact onto the opponent. This could be

linked to energy losses from soft tissue motion possibly being reduced by up to 50% by tensing muscles at contact.¹⁸ The ability to make a power grip becomes therefore essential in this terminal aspect of a punch phase, as an inability to do so due to pathology can result in decreased punch force and potentially cause further damage to the hand-wrist. In the Great Britain boxing squads, injuries to the hand-wrist account for 23.2% to 33.7% of all significant injuries resulting in the highest amount of time loss.⁸ It is therefore important to have robust objective measures to understand when potentially significant injuries are occurring.

Over a period of 5 years (2010-2014), hand-wrist function was assessed using the Takei dynamometer by measuring 2 components: (1) the peak strength produced by each boxer during a biannual screening process, producing a comparative baseline in a healthy state for the different weight categories and sexes, and (2) potential pathology assessed for individuals who had described symptoms in the area due to either a known or unknown mechanism of trauma. The aim of this article was to identify the Takei dynamometer as a valid and reliable outcome measure tool for hand pathology in a sport like boxing.

Methods

Data were collected retrospectively from the Great Britain Boxing Physiotherapy Injury records. The participants included all boxers at any time between January 1, 2010, and December 31, 2014. A total of 129 male and 31 female boxers (aged 23.7 ± 3.9 years) were included in the study. The boxers were in each Olympic weight category from 49 (light flyweight) to 91 kg (super heavy weight). Injuries were then grouped into 2 categories: hand and wrist. Hand injuries were classed from the tip of the distal phalanx to the base of the metacarpals. Wrist injuries were classed including carpometacarpal (CMC) joints, carpal bone and joints, distal radioulnar joint (DRUJ), and radiocarpal and ulnocarpal joints. For both categories, all significant soft tissue and bone injuries were included.

The Takei T.K.K.5401 GRIP-D handgrip dynamometer (Takei Scientific Instruments Co., Ltd, Tokyo, Japan) was used for all data collection. This was performed with the participants in standing, arm by their side with full elbow extension. All measurements were performed alternatively 3 times with no rest. For each measurement, the participant was asked to squeeze the dynamometer for 3 s. The peak value of strength was recorded. The current literature provides inconclusive evidence into the effects that posture, position of the upper extremity, and overall elbow position have on grip strength.^{11,17,18} Measuring grip strength is however very reproducible between days if a standard procedure is followed.¹⁷ This protocol was maintained by every practitioner. Fifty-four injuries in total were collected, with 27 classed equally for both the hand and wrist.

Table 2. Reliability of the Takei HG Dynamometer for Sex and Dominance.

	Measurement			ICC	95 CI (%)	n
	1st	2nd	3rd			
HG (total): men						
Left	49.2 ± 10.3	48.1 ± 10.1	47.6 ± 10.3	0.939	0.939-0.955	129
Right	49.1 ± 10.6	48.4 ± 10.7	48.0 ± 11.0	0.948	0.932-0.962	129
HG (total): women						
Left	36.4 ± 6.1	35.2 ± 6.1	34.5 ± 5.9	0.898	0.824-0.946	31
Right	36.0 ± 6.2	35.2 ± 6.4	34.0 ± 6.2	0.910	0.845-0.952	31

Note. ICC = intraclass correlation coefficient; CI = confidence interval; HG = hand grip.

The percentage difference between the boxers' left and right scores at baseline was compared against the percentage difference between the boxers' left and right scores after injury. The difference between baseline and postinjury scores was assessed using a paired *t* test. Reliability of each measure was examined using the intraclass correlation coefficient (ICC). The following benchmarks for ICC were used: "Poor" (0.00-0.20), "Fair" (0.21-0.40), "Moderate" (0.41-0.60), "Substantial" (0.61-0.80), and "Almost Perfect" (0.81-1.00) agreement.¹²

Results

An almost perfect correlation for the Takei hand grip dynamometer was found for all scores when used for both sexes, across all the Olympic weights, and for both sides (Table 2). There was no significant difference between left and right grip scores. When assessed for individual weight categories, the grip scores at baseline got progressively stronger as the weight of the boxer increased (Table 3).

Hand

The baseline measure had an average percentage difference of 6.3% when compared with postinjury measure with an average of 23.7% (Table 4). The difference between both measures was statistically significant ($P < .05$ by 2-tailed *t* test). Fractures and dislocation ($n = 4$) showed an average difference of 46% (24.2%-78.1%) when compared with baseline measures with an average of 6.2% (9.1%). Injuries to the metacarpophalangeal (MCP) joints showed a wide range. A difference of 6.9% was recorded at baseline with an even lower difference of 3.1% recorded after an injury of the fifth MCP. Contrastingly another fifth MCP joint injury indicated a difference of 40.2% after injury when compared with an 8.3% difference at baseline.

Wrist

The baseline measures had an average of 5.7% when compared with postinjury measures which had an average of

Table 3. Hand Grip Averages at Baseline for Olympic Boxers per Weight Category.

	Weight, kg	Left	Right
Men, n			
11	49	37.2 ± 5.6	38.2 ± 5.6
13	52	37.4 ± 3.3	38.3 ± 3.5
15	56	42.9 ± 6.3	41.2 ± 8.3
11	60	43.2 ± 4.3	41.2 ± 4.4
11	64	45.4 ± 5.5	45.0 ± 3.6
17	69	48.2 ± 4.8	48.9 ± 5.6
16	75	52.8 ± 4.5	54.4 ± 4.4
13	81	54.3 ± 7.9	53.4 ± 7.9
11	91	59.4 ± 7.7	60.8 ± 7.8
11	91+	63.4 ± 10.1	64.2 ± 10.9
Women, n			
13	51	35.6 ± 4.5	33.6 ± 5.7
12	60	35.0 ± 7.0	35.4 ± 6.2
6	75	38.3 ± 4.7	41.4 ± 1.4

34.5% (Table 5). The difference between both measures was statistically significant ($P < .05$ by 2-tailed *t* test). Most injuries recorded in this area occurred at the CMC joint and carpal bones ($n = 22$) with a percentage difference of 38.1% (7.7%-81.2%) when compared with baseline measure difference of 5.5% (1.0%-14.7%). This indicated a high percentage difference for injuries occurring in this region. Other injuries ($n = 5$) were recorded in the region between the radius-ulna and proximal carpal bones. A difference of 12% (2%-24%) after injury was recorded when compared with 6.3% (0.8%-15.8%) at baseline.

Discussion

The aim of this article was to identify the Takei dynamometer as a valid and reliable outcome measure tool for hand pathology in a sport like boxing. At the hand, fractures and dislocations were highly detected with an average difference of 40.2% ($P < .05$) when comparing postinjury measures with baseline measures. As these injuries occur in both training and competition, early detection is important

Table 4. Hand Injuries: Percentage Comparison of Baseline and Postinjury Data.

No.	Wt	BL	BR	DIFF (%)	PIL	PIR	DIFF (%)	Injury
1	52	40.4	41.5	2.7	35.1	41.5	15.4	Left 4th and 5th MCP joint sprain
2	75	54.9	53.6	2.4	50.4	54.5	7.5	Left 2nd MCP joint sprain
3	75	53.7	57.7	6.9	46.6	35.3	24.2	Right Undisplaced crush fracture base of 5th MC bone
4	69	45.7	48	4.8	45.4	29.6	34.8	Right 2nd MCP joint sprain with RCL sprain
5	75	51.3	54.4	5.7	28.1	59.7	52.9	Left 2nd MCP sprain
6	91	66.5	55.1	17.1	62.3	50.1	19.6	Right 3rd MCP sprain
7	69	54.6	54.3	0.5	45.3	21.6	52.3	Right Fractured base 5th MC bone
8	91+	54.2	58.2	6.9	55.6	53.9	3.1	Right 5th extensor hood bruising/edema
9	91	67.3	67.7	0.6	61.3	57.2	6.7	Right Extensor hood tear
10	81	66.3	67.3	1.5	54.5	53.0	2.8	Right Extensor hood injury
11	60	45.3	44.2	2.4	41.4	31.1	24.9	Right 3rd MCP joint sprain
12	60	45.3	44.2	2.4	40.4	41.4	2.4	Right 2nd MCP extensor tenosynovitis
13	91+	74.5	78.2	4.7	74.6	69.6	6.7	Right 3rd MCP joint sprain
14	69	43.2	39.6	8.3	41.0	28.9	29.5	Right 1st MCP joint dislocation
15	69	43.2	39.6	8.3	41.5	24.8	40.2	Right 5th MCP joint sprain
16	81	39.7	40.5	2.0	56.4	49.4	12.4	Right 3rd joint MCP sprain/capsule synovitis
17	91	34.2	39.6	13.6	46.0	55.0	16.4	Left 5th MCP joint sprain with soft tissue bruising
18	81	63.7	70.1	9.1	66.7	14.6	78.1	Right Fractured base 3rd MC bone
19	60	47.6	40.6	14.7	50.3	41.6	17.3	Left 2nd MCP extensor tenosynovitis
20	56	35.6	39.2	9.2	28.4	36.9	23.0	Left 3rd MCP joint sprain
21	56	35.6	39.2	9.2	29.3	37.6	22.1	Left 3rd MCP joint sprain
22	56	39.4	40.7	3.2	44.5	33.1	25.6	Right 2nd-4th MCP joint sprain and soft tissue bruising
23	56	39.4	40.7	3.2	18.0	25.0	28.0	Left Ruptured UCL 1st IP joint
24	64	42	47.5	11.6	45.4	44.0	3.1	Right 3rd MCP joint sprain
25	69	48	48.9	1.8	52.2	51.6	1.1	Right 2nd MCP joint sprain
26	56	53.3	55.5	4.0	29.6	48.9	39.5	Left 3rd MCP joint sprain
27	60	44.2	47.7	7.3	40.9	33.5	18.1	Right 3rd-5th MCP joint sprains

Note. Shaded area = injured side; Wt = weight (kg); BL = baseline left (kg); BR = baseline right (kg); DIFF = percentage difference between left and right; PIL = post injury left (kg); PIR = post injury right (kg); MCP = metacarpophalangeal; MC = metacarpal; RCL = radial collateral ligament; UCL = ulnar collateral ligament; IP = interphalangeal.

to prevent further damage to the area. Soft tissue injuries at the MCP joint showed a variation of results, indicating this tool as not valid in accurately detecting these pathologies. From the injury reports, it was however observed that when a significant percentage difference was recorded in these areas, the handheld dynamometer was used as an effective clinical objective measure. This provided safe guidance of injury progression till resolution of symptoms.

At the wrist, CMC and carpal joint injuries were highly detected with an average difference of 32.6% ($P < .05$) when comparing postinjury measures with baseline measures. Injuries in these regions have been reported as having the greatest impact on training availability.¹⁴ It is therefore important to have an objective clinical tool that assists in diagnosing an injury to these areas, and guide management. Injuries at the DRUJ indicated a smaller but still significant percentage average difference of 12% when compared with 6.3% at baseline. When compared with CMC and carpal injuries, DRUJ injuries impact less on training availability.¹⁴ DRUJ injuries still require

appropriate interventions and monitoring to prevent subsequent regression of the pathology.

The Takei handheld dynamometer was found to be highly reliable using the protocol described in this study. This protocol was maintained by each practitioner for every boxer tested. There has been research into the effects that posture, position of the upper extremity, and overall elbow position have on grip strength. One study found that there was no statistical difference between grip strength when measured at 0°, 30°, 60°, and 90° of elbow flexion.¹⁷ Similarly, another study found that grip strength was unaffected by position when tested in seated, supine, and standing positions.¹⁸ Another study observed some differences on grip strength values by altering differences between elbow, shoulder, and forearm positions.¹¹ Measuring grip strength is very reproducible between days if a standard procedure is followed.¹⁷ Based on the current literature and lack of conclusive evidence regarding the best testing position, the hand grip dynamometer can be a highly reliable tool if it is used with a procedure and testing position that

Table 5. Wrist Injuries: Percentage Comparison of Baseline and Postinjury Data.

No.	Wt	BL	BR	DIFF (%)	PIL	PIR	DIFF (%)	Injury
1	75	54.9	53.6	2.4	58.4	53.9	8	Right 5th CMC joint sprain (mild)
2	75	54.9	53.6	2.4	58.5	37.4	36	Right Fractured hamate and 5th CMC joint subluxation
3	52	35.1	35.4	0.8	35.5	33.6	5	Right Mild wrist jarring
4	51	29.3	26.3	10.2	29.6	27.0	9	Right 2nd CMC joint sprain
5	75	59.7	55.6	6.9	52.9	47.4	10	Left Wrist jarring with radiocarpal ligament sprain
6	75	59.7	55.6	6.9	56.9	44.7	21	Right 5th CMC joint sprain with hamate bruising
7	75	59.7	55.6	6.9	53.7	35.8	33	Right 5th CMC joint sprain with hamate bruising
8	75	59.7	55.6	6.9	56.7	8.4	85	Right 3rd and 4th CMC joint sprain (grade 2)
9	75	59.7	55.6	6.9	48.1	16.6	65	Right 3rd and 4th CMC joint sprain (grade 2)
10	91	54.2	58.2	6.9	42.7	57.2	25	Left 2nd CMC joint sprain (mild)
11	56	44.2	37.2	15.8	29.8	39.3	24	Left ECU tendinitis
12	60	45.3	44.2	2.4	41.1	12.7	69	Right 3rd CMC joint sprain/avulsion fracture base 3rd MC
13	60	45.3	44.2	2.4	33.9	42.5	20	Left 2nd and 3rd CMC joint sprain
14	60	45.3	44.2	2.4	43.8	37.3	15	Right Distal carpal jarring (capitate/trapezoid)
15	64	43.8	44.9	2.4	19.9	42.1	53	Left 2nd and 3rd CMC joint sprain
16	64	43.8	44.9	2.4	22.0	46.5	53	Left 2nd and 3rd CMC joint sprain/instability
17	60	47.6	40.6	14.7	44.3	14.0	68	Right 2nd and 3rd CMC joint sprain
18	60	47.6	40.6	14.7	49.4	36.6	26	Right Midcarpal instability/2nd and 3rd CMC sprains
19	81	55.4	54.3	2.0	52.0	53.2	2	Left Ulnar-lunate impaction
20	64	50.7	50.2	1.0	50.5	29.4	42	Right 2nd and 3rd CMC joint sprains
21	64	42	47.5	11.6	40.7	31.5	23	Right 2nd CMC joint sprain
22	60	41.4	42	1.4	45.3	32.9	27	Right 3rd CMC joint sprain
23	60	41.4	42	1.4	42.3	32.4	23	Right 3rd CMC joint sprain
24	69	48	48.9	1.8	49.3	38.3	22	Right Multiple injuries throughout carpal joints
25	69	48	48.9	1.8	46.3	38.3	17	Right DRUJ joint stiffness
26	56	53.3	55.5	4.0	24.0	47.6	50	Left 2nd CMC joint sprain
27	56	53.3	55.5	4.0	46.1	23.8	48	Right 2nd and 3rd CMC joint sprains

Note. Shaded area = injured side; Wt = weight (kg); BL = baseline left (kg); BR = baseline right (kg); DIFF = percentage difference between left and right; PIL = post injury left (kg); PIR = post injury right (kg); CMC = carpometacarpal; MC = metacarpal; ECU = extensor carpi ulnaris; DRUJ = distal radioulnar joint.

can be easily reproducible. Great Britain boxing used the position of 0° shoulder flexion, shoulder adducted, elbow extended, and forearm in a neutral position.

The information from this current study indicates that grip strength, which is an important aspect of hand function, is affected by pathology in boxing. Baseline data are therefore important to compare data between sides after injury. Comparing unaffected and affected sides at the time of injury using the handheld dynamometer provided a very useful clinical criterion for further management. From the data collected, a recommendation that up to about 15% difference between left and right hand/wrist can be considered normal, with the majority of reading expected to fall below 10%. A difference of 20% is indicative of a form of pathology, although pathologies can also be present with lower difference or no apparent changes. That is why a comparison with baseline, especially in the sporting environment, can provide more accurate information. A difference of >20% with a suspicion of fracture/dislocation/ligamentous rupture should be considered for investigation. Although this study was

performed in boxing, the hand grip dynamometer should be considered as a useful objective marker for injury assessment and progression in other sports.

Conclusion

In this cohort of elite amateur boxers, the Takei handheld dynamometer was found valid and reliable in detecting significant injuries occurring at the hand and wrist anatomical regions. Fractures and dislocations at the hand, followed by soft tissue injuries at the CMC and carpal bones, are more highly detected than any other injury incurred in boxing. MCP joint injuries vary between individuals with the handheld dynamometer providing additional useful information to symptoms described. Further research into other sports is required to fully understand the role of grip strength and pathologies.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

As the data are anonymized, no informed consent was obtained.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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