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Comparison of the Training Loads of Mixed Martial Arts Techniques in Isolated Training and Open Sparring

Christopher Kirk[1(A,B,C,D)], **Howard T Hurst**[2(A,C)], **Stephen Atkins**[2(A)]
Burnley College Human Performance Centre Lancashire, United Kingdom

Key words: MMA; training intensity; accelerometry; playerload; combat sports

Summary

Introduction. Body worn accelerometry has been shown to be reliable in measuring training Intensity in several sports including MMA and has been used to assign training intensity in sports such as football and rugby, but not in MMA.

Material and methods. Eight male MMA trained participants (age 25.5±4.5 yrs) were equipped with a Catapult Minimax x3 accelerometer between the T3 and T4 vertebrae and completed a series of MMA specific movements in isolation and a MMA sparring bout each (3 x 5 minute rounds). Mean playerload was recorded for each isolated movement and the equivalent movements in the sparring bouts.

Results. Paired sample t tests ($p \leq 0.05$) found that jabs, crosses and left hooks had significantly higher playerload in isolation that in sparring, single leg takedowns have higher playerload than double leg takedowns in isolation but not in sparring, whilst takedowns cause significantly greater playerload than strikes in both isolation and sparring according to one way ANOVA ($p \leq 0.05$). It was also found that there is no difference in playerload between an unsuccessful takedown and a successful takedown in sparring, either for the offensive participant or the defensive participant.

Conclusions. These results demonstrate the differences in movements in MMA AND can be used to more accurately prescribe training intensity.

Introduction

Mixed martial arts (MMA) is becoming an increasingly popular combat sport in which participants use a series of kicks, punches and grappling manoeuvres to overcome their opponents [1,2]. However, despite its growing popularity there remains a lack of research regarding the training methods and the efficacy of these methods for the competitors [3,4]. Several studies have attempted to design training protocols for MMA based on laboratory test results and comparisons of the movement requirements to other sports [5,6,7]. However, there is relatively little peer reviewed data available from field based testing regarding the movement intensity of MMA [8,9, 10] and none comparing the differing intensities of training movements to in-competition movements. It has been argued that individual sports need to have their own training methods and modalities to ensure success and basing these on different sports could be a mistake [11,12]. To this end, it is important that the intensities of different movements of MMA training and competition are measured and compared to ensure training protocols can be accurately described and assigned to ensure optimal athlete preparation, monitoring of fatigue and injury minimisation [13,14].

Wearable accelerometry has been used to quantify the in-competition intensities of several sports [15,16,10] as well as the effects of different training intensities on performance [17, 18,19]. These systems use triaxial accelerometers to determine the magnitude of accelerations in three cardinal planes [20,21] and their reliability has been previously reported under both laboratory and field conditions [20,22,23]. Accelerometers have also been found to be reliable in the assessment of MMA specific movements (CV = 2.4% - 7.8%, ICC = .700 – 970) [24]. Therefore, the aim of this study was to record and compare the intensities of different MMA specific movements in training and sparring to determine if any differences exist between training and competition.

Material and methods

Eight trained male MMA competitors (age 25.5 ± 4.5 yrs; stature 176.40 ± 9.4 cm; mass 74.9 ± 13.1 kg; all right hand dominant) participated in the study. Participants had all taken part in at least 4 professional or semi-professional MMA bouts at either regional or national standard in the UK. All participants were allowed a familiarisation session prior to testing and were instructed to refrain from alcohol for two days prior to testing and to eat a breakfast that would be typical for a competition day. Ethical approval was granted by the University of Central Lancashire's Research Ethics Sub-Committee, in accordance with the Declaration of Helsinki. Written and informed consent was obtained from all participants prior to the study.

Participants were equipped with 7 ounce MMA sparring gloves, shin and instep pads, MMA shorts, a groin protector, gum shield and a t-shirt or rash guard. Triaxial accelerometers with a sampling rate of 100 Hz (Minimax X3, Catapult Innovations, Australia) were used to record external load, and were placed in a neoprene harness worn on the torso, positioning the unit at the T3-4 vertebrae. The harness was then secured in place using duct tape to prevent movement on the body during the grappling phases of testing. For each stage of testing the accelerometers were used to record the playerload (PLd – the total external load of an individual movement calculated from the magnitudes of accelerations in the X, Y and Z axes) of each movement which is expressed in arbitrary units (au).

Participants were required to perform a series of isolated standing and ground strikes as would be performed during a typical training session. Prior to each set of five strikes the participants were instructed to stand in a neutral position for 30 seconds to allow a clear distinction to be made between sets. Participants were required to perform 5 jabs (punch with the lead hand), 5 crosses (punch with the rear hand), 5 left hooks (punch in a transverse plane at head height with the lead hand), 5 right hooks (punch in a transverse plane at head height with the rear hand), 10 leg kicks (a turning kick at thigh height, 5 left then 5 right), 10 body kicks (a turning kick to the torso, 5 left then 5 right) and 10 high kicks (a turning kick at head height, or as high as they are able, 5 left then 5 right). The punch bag was then laid flat on the ground and participants sat on the bag in a full mount position (Figure 1) to complete 5 left and 5 right punches.

Participants were then paired up with someone of approximately the same body mass. Both participants took turns to complete 5 double leg takedowns and 5 single leg takedowns. Each takedown was a complete technique in that the offensive participant continued until their partner was grounded. Again, following each set of takedowns participants were instructed to return to a neutral position for 30 seconds to allow clear delineation between efforts. Data were recorded for both

Figure 1. Participant in full mount position

the participant completing the takedown (offensive) and the participant being taken down (defensive).

Due to a reoccurrence of a pre-existing injury to one of the participants, only six participants completed the following test which took place 30 minutes after completion of the isolated movement testing. Participants took part in a single simulated competition bout in a 17 foot competition standard MMA cage under unified MMA rules modified for the participant's safety (3 X 5 minute rounds, 1 minute rest between rounds, no elbows or knees to the head). Participants were paired based on comparable stature and mass for each bout. If a submission occurred or either participant was considered to have been placed in an inescapable, indefensible position, both participants were to return to their feet and immediately continue the bout. The bouts were recorded in their entirety using a tripod based Samsung HMX-F80 camcorder (Samsung, Seoul, South Korea) to allow accurate determination of the data for each technique used in the bouts.

Prior to statistical analyses, accelerometry data were downloaded and identified using Catapult Sprint 5.0.9 software (Catapult Innovations, Melbourne, Australia). The mean± SD of each technique in isolation and in sparring was calculated and recorded. Normal distribution of data was confirmed using a Shapiro-Wilk test ($p \geq 0.05$).

Paired samples t tests were used to determine any differences in the PLd of the following variables: each isolated technique and the same technique in sparring; punches and kicks in isolation; single leg takedowns and double leg takedowns in isolation (for both the offensive participant and the defensive participant); standing punches and grounded punches in isolation; standing punches and grounded punches in sparring; single punches and kicks in sparring; punch and kick combinations in sparring; left sided techniques and right sided techniques in isolation; left sided techniques and right sided techniques in sparring, successful and unsuccessful takedowns in sparring (for both the offensive participant and the defensive participant); successfully completing a takedown and unsuccessfully defending a takedown in sparring. Effect size (ES) was calculated for the t tests using Cohen's *d* with a small $d \geq .20$, a moderate $d \geq .50$ and a large $d \geq .80$ [25]. One way ANOVA was used to determine any differences in the following: punches, kicks and takedowns in isolation; punches, kicks and takedowns in sparring. ES for the ANOVA was calculated using eta² (η^2) with a small $\eta^2 \geq .10$, a moderate $\eta^2 \geq .25$ and a large $\eta^2 \geq .40$ [25]. Significance for each of the named tests was set at an alpha level of $p \leq 0.05$ level, and data were analysed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA).

Results

Table 1 summarises the mean±SD PLd for each technique observed as well differences between the named techniques in isolation and sparring according to paired samples t tests and Cohen's *d.* The paired samples t-tests found that only the following categories had significant differences between isolation and open sparring: jab ($t_{(5)}$= 4.105, p= 0.009); cross ($t_{(5)}$= 3.599, p= 0.016); left hook ($t_{(5)}$= 2.611, p= 0.048). However, the following variables had high ES: jab *d* = 2.12; cross *d* = 1.57; left hook *d* = 0.92; right body kick *d* = 0.92; right high

Table 1. Comparison of PLd of Individual Techniques Used in Sparring Bouts and in Isolation

Technique	PLd of Techniques in Sparring (au)	PLd of Techniques in Isolation (au)	ES Cohen's *d*
Jab *	2.04 ± .29	2.88 ± .37	Π
Cross *	2.25 ± .26	3.37 ± .54	Π
Left Hook *	2.48 ± .31	3.18 ± .40	Π
Right Hook	2.54 ± .65	3.21 ± .41	Δ
Left Leg Kick	1.86 ± .04	2.38 ± .63	Δ
Right Leg Kick	1.93 ± .24	2.19 ± .65	
Left Body kick	1.72 ± .27	2.34 ± .72	
Right Body Kick	1.95 ± .42	2.25 ± .38	Π
Left High Kick	1.98 ± .75	1.88 ± .67	
Right High Kick	1.61 ± .41	2.10 ± .35	Π
Left Ground Punch	1.25 ± .22	2.10 ± .35	
Right Ground Punch	1.62 ± 0	3.00 ± .44	
TD Double Leg Attempt (Attacker)	3.85 ± .86	N/A	
TD Double Leg Successful (Attacker)	3.81 ± .80	5.29 ± 1.15	Π
TD Double Leg Attempt (Defender)	2.66 ± .50	N/A	
TD Double Leg Successful (Defender)	4.95 ± 1.71	4.69 ± 1.43	Δ
TD Single Leg Attempt (Attacker)	7.50 ± 0	N/A	
TD Single Leg Successful (Attacker)	4.66 ± 0	4.46 ± 1.20	
TD Single Leg Attempt (Defender)	3.73 ± 0	N/A	
TD Single Leg Successful (Defender)	4.72 ± 0	4.53 ± 1.08	
Punch Combination	2.85 ± .35	N/A	
Kick Combination	2.10 ± .47	N/A	

Nb. Techniques with a ± SD of 0 displayed had only one occurrence in the sparring bouts and were not used in the paired samples t test. Variables marked with a * symbol showed significant differences ($p \leq .05$) in the paired samples t test. Variables with a large ES (large $d \geq .80$) are marked with a Π symbol and variables with a moderate ES ($d \geq .50$) are marked with a Δ symbol. TD = takedown.

kick d = 1.41; left punch d = 2; double leg takedowns offensive d = 3.54. The following variables had moderate ES: right hook d = 0.78; left leg kick d = 0.75; left body kick d = 0.72; TD double leg defensive d = 0.58. All other variables demonstrated low ES.

Within isolated training movements, standing punches and ground punches were found to result in significantly different PLd production ($t_{(74)}$ = 6.286, p=0.000, d = 0.94), as did offensive single leg takedowns and offensive double leg takedowns ($t_{(34)}$ = 2.586, p = 0.014, d = 0.71). The t tests between isolated punches and kicks ($t_{(154)}$ = -13.833, p=0.000, d = -1.62) and defending single leg takedowns and defending double leg takedowns ($t_{(39)}$ = 0.640, p = 0.526, d = 0.13) did not reveal any significant differences in the amount of load experienced by the participants. One way ANOVA found significant differences with a large ES in the PLd produced by punches, kicks and takedowns within isolated training ($F_{(2,447)}$ = 397.480, p = 0.000, η^2 = 0.64).

For the sparring bouts, the PLd of punches and kicks were found to be significantly different ($t_{(21)}$ = 2.517, p = 0.020, d = 0.95), as was the PLd of standing punches and ground punches ($t_{(3)}$ = 4.971, p = 0.016, d = 2.24). T tests on the following variables did not reveal any significant differences in PLd: punch combination and kick combination ($t_{(1)}$ = 3.413, p = 0.181, d = 3.20); successful offensive takedown and unsuccessful offensive takedown ($t_{(1)}$ = 0.20, p = 0.987, d = 0.03); successful defensive takedown and unsuccessful defensive takedown ($t_{(1)}$ = -1.390, p = 0.397, d = -1.12); successfully completing a takedown and unsuccessfully defending a takedown ($t_{(6)}$ = 1.029, p = 0.343, d = 0.40). There were, however, significant differences with a high ES in the PLd produced by punches, kicks and takedowns within the sparring bouts according to one way ANOVA ($F_{(2,53)}$ = 47.307, p = 0.000, η^2 = 0.64).

When comparing left sided techniques to right sided techniques, there were no significant differences in PLd in either the isolated movements or the sparring movements. Isolation techniques: ground punches ($t_{(14)}$ = -4.201; p= 0.001, d = -0.70); standing punches ($t_{(14)}$ = -1.30; p= 0.215, d = 0.50), kicks ($t_{(21)}$ = .567; p= 0.577, d = 0.12). Sparring movements: standing punches ($t_{(10)}$ = -1.162, p = 0.272, d= -0.34); kicks ($t_{(11)}$ = -0.139, p=.892, d= -0.06). There were not enough occurrences of right ground punches within the sparring to conduct a t test on this variable.

Discussion

This study represents the first investigation into the intensities of individual MMA specific movements in both isolation and open sparring. Whilst takedowns resulted in the highest PLd recordings overall, with single leg offensive takedowns being the highest, isolated training techniques result in higher PLd than the equivalent movements in sparring (with the exception of left high kick), although this was not always statistically significant. Whilst jab, cross and left hook were the only techniques to have statistically significant differences in PLd in isolation, six other techniques did show moderate to high ES. This suggests that with a greater sample size, there could be more techniques that have significant differences in the load placed on the participant so still need to be considered when constructing a training session or programme. The lower PLd in the sparring bouts could be explained by the fact that the participants are attempting to perform the techniques against a live opponent rather than a fixed punching bag. This could cause the technique to be altered as the participant may not want to fully commit to the movement in case they are countered by the opponent or the opponent moves completely. This alteration of movement could be of concern to coaches whose focus is the application of consistent technique throughout training and competition, especially with novice participants [26].

Understanding which movements within a sport are performed with the greatest intensity is a vital step in fatigue and injury management for coaches [13, 14]. Within isolated technique training, punching drills and kicking drills did not result in significantly different amount of PLd, however, there were differences between punches, kicks and takedowns. This suggests that any training session that includes takedowns will result in greater intensity levels than training sessions that do not. Similarly, offensive single leg takedowns caused significantly higher PLd that offensive double leg takedowns, where as a participant who is being taken down will experience equal intensity regardless of the takedown type being used. Finally standing punches resulted in higher PLd than grounded punches, most likely due to the hips and torso having reduced movement during grounded strikes and therefore lower accelerations. In practice, these results suggest that the amount of intensity caused by a skills training session in MMA will be highest when incorporating takedown drills with striking drills, moderate when takedown drills are excluded and lowest when only ground striking movements are trained.

When looking at the differences in PLd per technique in the sparring bouts, it was found that punches, kicks and takedowns resulted in significantly different amounts of intensity whilst amongst strikes, punches caused significantly greater intensity than kicks. This again could be caused by the participants not wanting to fully commit to a technique that could be more easily countered by the opponent (kicks), thus putting them in a losing position. This could also be a reason for ground punches PLd to be lower than standing punches PLd in the sparring, seeing as well as the aforementioned hip and torso mobility, punching in a grounded position allows the opponent more chance of countering and gaining a better position [1], making it riskier for the offensive participant to attempt a large, load inducing movement. Amongst live takedowns in sparring, it made no significant difference to the amount of intensity experienced whether a takedown was successful or unsuccessful. Similarly, when defending a takedown, the affect on PLd was the same whether the takedown was defended successfully or not. This demonstrates that whenever a participant in MMA is involved in wrestling based movements, either offensively or defensively, they will be experiencing greater levels of intensity than in a purely striking session. As takedown techniques have been shown to be a key deciding factor in success in MMA [10] it is important that coaches understand the effect they have on the intensity levels of their athletes and can plan training sessions/programmes accordingly.

Finally, there were no differences in the amounts of PLd experienced between the participant's dominant or non-dominant side which suggests that MMA competitors are more similar to judokas and wrestlers who were found to have bilateral symmetry in strength, balance and power [27]. This means that training patterns and programmes can be developed and used without having to account for whether the athlete is left or right sided. This is supported by research that concluded that there are no significant differences in success in MMA due to lateral preference [28].

Conclusions

Understanding how different movements within a sport affect and alter the athlete's training intensity is vital to planning and executing training sessions that maximise improvements whilst minimising fatigue and injury risk [13,14,21]. This study records the PLd of several MMA related skills and highlights which would cause the greatest increases in intensity in isolated skills training and in open sparring. This provides a database for coaches to use as a guide to plan training sessions to meet the optimum intensity for that stage of the overall training macrocycle. This database can be added to over time through further research. It also demonstrates that any session that includes takedowns (either against a passive or active training partner) will increase the intensity significantly and that techniques performed in isolation result in greater intensity than those in sparring. This, however, does not take into account the internal load experienced during training sessions, which must still be considered to allow efficient athlete preparation.

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Address for correspondence:
Christopher Kirk
Burnley College
Princess Way, Burnley, Lancashire, United Kingdom
Email: c.kirk@burnley.ac.uk
Telephone: 01282 733498

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