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Movement and physiological demands of amateur mixed martial art fighting

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ABSTRACT

To quantify in-competition physiological loads of amateur mixed martial arts (MMA), we recruited 10 male MMA athletes (Age: 27.3 ± 3.3 y; mass: 79.5 ± 0.5 kg; height: 1.77 ± 0.04 m) training 9 ± 4 h.wk. Athletes were filmed during 3 x 5 min competitive rounds while notational analysis was performed post-fight using referee head-mounted camera video-recordings. Standing punches including elbows thrown, kicks attempted and landed, and accumulated time-fighting while standing, clinching and grappling (wrestling on the ground) were quantified. Athletes' heart rates were measured between rounds, while athletes' earlobe sampled blood lactate and perceived exertion (RPE) were recorded immediately post-fight. Results demonstrated 39 ± 18 punches were thrown/round, but only 20 ± 11 (47 ± 20%) of these were landed. In comparison, each round, 11 ± 7 kicks were attempted, and 5 ± 5 (48 ± 20%) of these struck the opponent. Similar proportions of the fight were spent wrestling on the ground (40 ± 23 %). and standing while punching/kicking (39 ± 18 %). Blood lactate was 12.0 ± 2.8 mmol.L^{-1} and the athletes' RPE indicated fights were hard or very hard (16 ± 2 a.u.). Similar heart rates were achieved after each round (176 ± 7, 175 ± 14, 177 ± 11 beats.min). The proportionally higher amount of time spent grappling on the floor and fighting while standing indicates a higher training priority for these fight components. This research will assist coaches in developing training protocols replicating or exceeding demands of amateur MMA.

1. Introduction

One of the major challenges faced by coaches in sport is to determine how their athletes' training equates to expected competition demands. While quantification of training demands is relatively easy, the practicalities of some sports such as Mixed Martial Arts (MMA) limit both the measurement devices available and the opportunities to collect data during actual competition. As a compromise, many researchers have simulated game demands to estimate what would likely be found in competition and have used less than optimal measurement techniques, for instance Crisafulli et al. (2009) used a preset routine of strikes and movements with a compliant opponent to obtain measures of oxygen uptake with a portable gas analyzer. Other researchers have focused on measuring physiology of participants outside of the competitive environment with tests purported to relate to the competition demands (Schick et al., 2010). However, there is no doubt that time motion analysis combined with physiological measurements taken during competition is a superior method for defining competition demands (Abdelkrim, et al., 2007).

Obtaining unobstructed video footage of MMA fighting presents unique challenges as the athletes are constantly moving and fixed cameras outside of the ring are likely to miss recording some fight details. The referee is within the ring and is the closest to the fight. Therefore, the referee has the optimal view from which to record the fight. Fortunately, the miniaturization and improved stabilization of technology has enabled cameras to be mounted on officials to provide researchers with this perspective.

In order to establish the effectiveness of training methods it is imperative coaches have good understanding of a sport's demands. Therefore, to help address the relative lack of MMA in-competition data, the current study employed a referee head-mounted camera to capture time-motion analysis data while also getting permission to access the ring during and immediately post fight to collect physiological data. Hence, the objective of our study was two-fold: Firstly, to provide strength and conditioning coaches with physiological and fight reference data to help design more effective training programs. Secondly, and

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more importantly to provide field practitioners with an example of how to collect this data for their own athletes.

2. Methods

2.1. Participants

Ten elite amateur MMA athletes volunteered for the study (age: 27.3 ± 3.3 years; mass: 79.5 ± 0.5 kg; height: 1.77 ± 0.04 m), with a combined MMA record of 4 ± 3 wins and 2 ± 2 losses (mean ± SD). The experimental protocol was approved by the University of Canterbury Human Ethics Committee (Christchurch, New Zealand), and all participants were informed of the risks involved in the study before their written consent was obtained.

2.2. Apparatus

Within the one minute inter-round rest period and post-fight, each athlete's heart rate was recorded using a Polar FS1 heart rate monitor (Polar, Finland) and Polar T31 heart rate chest belt attached to a handheld swimbar (Polar, Finland) that was pushed against the athletes chest. The use of the T31 is common for both exercise evaluations and medical research, and it has been shown to be both accurate and reliable (Montes and Navalta, 2019). Immediately post fight, (athletes provided a perceived rating of exertion (RPE) and had an earlobe blood lactate sample taken (within 3 minutes) using a Lactate Pro analyser (Lactate Pro, Arkray, Japan). The Lactate Pro has been shown to display good reliability and accuracy compared with a criterion laboratory analyser (Tanner et al., 2010).

After the contest, notational analysis was performed on the video recordings from a referee head-mounted camera (Go Pro™, San Mateo, CA, USA). This quantified fight variables including both attempted and successful standing punches and kicks as well as the proportion of time spent in various fighting components.

2.3. Task

As MMA athletes, all participants adhered to a controlled diet to meet a specified weight to compete as directly by their coach and adhered to other pre-fight preparations provided by their manager. This included refraining from any form of exercise 24 hours prior to the contest. Each participant was weight matched with an opponent in a full-contact contest lasting three rounds of 5 min each. MMA fights often do not last the full scheduled duration. Therefore, in the present study if a participant received a lesion or any form of concussion that was deemed too dangerous to continue with (diagnosed by a clinical physician onsite), the contest was halted immediately. However, to gain a complete understanding of the physiological stress accompanying a longer length contest, barring a medical intervention, the entire contest duration was completed where possible.

2.4. Statistical Approach

Descriptive data was analyzed (mean ± SD) for each round of the fight. The magnitude and direction of the difference between winning and non-winning fighters was also calculated using a standardized effective size statistic ± 90% confidence limit. The criteria employed for interpreting effect size were: <0.2 *trivial*, 0.2-0.6 *small*, 0.6-1.2 *moderate*, and 1.2-2.0 *large* (Hopkins, 2002). A one-tailed paired *t* test was performed between groups of winning and losing fighters for all variables.

3. Results

Four of the five fights completed all three rounds, and went to the judges decision. One fight was stopped on advice from the ringside physician for medical reasons in the third round. Of the total fight time, similar proportions were spent wrestling on the ground and standing while punching/kicking with the least time spent clinching when standing (Table 1). Winning fighters landed more punches particularly in the first two rounds, and this is highlighted by the large magnitude of difference in punches landed when compared to those fighters that lost their fight. Heart rate data varied little between rounds and between winning and losing fighters, while the overall perceived exertion was rated between hard and very hard and was similar between winning and non-winning fighters. Nonetheless, blood lactate measured post fight was moderately (~2.3 $mmol \cdot L^{-1}$) higher in losing fighters (see Table 2).

Table 1: Mean time and percentage (± SD) of fight spent in different activities

	Round 1	Round 2	Round 3	Mean
Standing (s)	116 ± 44	94 ± 77	121 ± 38	110 ± 54
(%)	40 ± 15	37 ± 30	41 ± 13	39 ± 18
Grappling (s)	63 ± 29	50 ± 42	71 ± 45	61 ± 35
(%)	21 ± 10	20 ± 16	24 ± 15	21 ± 12
Wrestling (s)	114 ± 72	113 ± 68	100 ± 23	109 ± 64
(%)	39 ± 25	44 ± 26	34 ± 23	40 ± 23

4. Discussion

Our primary study objective was to provide strength and conditioning coaches with physiological and fight reference data to help design more effective training programs. The current MMA athletes rated their perceived exertion as being between hard and very hard, physiologically they had sustained high heart rates across all three rounds, and had a moderately high lactate reading post-competition. These measures all fell within the wide range of results previously reported by Amtmannet et al. (2003). Therefore, our findings agree with Braswell et al. (2010) who found a high level of physical fitness is essential for performance in MMA. Overall compared to this first round ~40% less kicks were performed in the second and third rounds. Yet, the greatest magnitude of difference between winning and losing fighters were the number of punches landed especially in the first two rounds.

The physiological and notational demands that we have highlighted above help explain recent findings that MMA induces significant fatigue and muscle damage that persists for greater than 24 hours after a competition (Ghoul et al., 2019). Therefore if using this data to replicate competition demands during training, it is advisable that strength and conditioning coaches also consider incorporating post training recovery interventions especially leading into a fight (Lindsay, et al., 2017).

A major limitation of this study was that no female MMA athletes were included so there is no evidence of what their physiological competition demands may entail. With the popularity of MMA growing (Spanias, et al., 2019), it is important that female data is captured to provide specific training guidelines. Nevertheless, this study addresses Cronin and the late Gordon Sleivert's challenge to sport scientists to formulate research designs that result in meaningful and practical information that assists coaches and strength and conditioning practitioners in the development of their athletes (Cronin & Sleivert, 2005). In this respect, the findings of the present study highlight the importance of landing punches in the first two rounds for this sample of amateur MMA athletes. Furthermore, we highlight the time spent in different fight components and detail the typical heart rate and lactate response of competitive fighting, thereby providing reference data upon which to monitor and modify training intensities. Future studies should consider further refining the notational analysis to include aspects such as whether punches are thrown whilst on the ground or from a standing position.

Finally, in addressing our second objective, this study provides coaches working with MMA athletes a valuable example of how to incorporate novel technology (head mounted camera) to collect data for notational analysis on their own athletes to assess key performance indicators relevant to their athlete's competitive level. Additionally, coaches are encouraged to collect physiological data during training enabling them to judge the extent to which their training matches competition demands.

Table 2: Physiological and MMA specific contest variables, with P-value and effect sizes between winning and losing fighters

Variable	All fighters (n = 10)	Winners (n = 5)	Losers (n = 5)	P-value	Effect size ± 90% CI	Interpretation
Round 1						
Heart rate (beats·min^{-1})	176 ± 7	176 ± 6	176 ± 9	*0.19*	0.03 ± 0.00	*Trivial*
Punches thrown (#)	42 ± 17	49 ± 7	36 ± 22	*0.15*	0.92 ± 0.07	*Moderate*
Punches landed (#)	22 ± 12	28 ± 10	16 ± 11	*0.07*	1.22 ± 0.12	*Large*
Kicks (#)	15 ± 9	18 ± 11	11 ± 5	*0.10*	0.94 ± 0.07	*Moderate*
Kicks connecting (#)	8 ± 6	11 ± 8	5 ± 2	*0.12*	1.14 ± 0.11	*Moderate*
Round 2						
Heart rate (beats·min^{-1})	175 ± 14	175 ± 11	174 ± 17	*0.39*	0.10 ± 0.00	*Trivial*
Punches thrown	31 ± 15	37 ± 10	24 ± 18	*0.09*	0.89 ± 0.06	*Moderate*
Punches landed	15 ± 11	23 ± 8	8 ± 8*	*0.01*	1.81 ± 0.27	*Large*
Kicks (#)	9 ± 6	10 ± 7	8 ± 6	*0.27*	0.22 ± 0.00	*Small*
Kicks connecting (#)	3 ± 2	3 ± 2	3 ± 2	*0.21*	0.33 ± 0.01	*Small*
Round 3						
Heart rate (beats·min^{-1})	177 ± 11	176 ± 11	179 ± 13	*0.35*	-0.19 ± 0.00	*Trivial*
Punches thrown	45 ± 19	49 ± 7	42 ± 27	*0.30*	0.45 ± 0.02	*Small*
Punches landed	22 ± 12	26 ± 12	18 ± 12	*0.26*	0.69 ± 0.04	*Moderate*
Kicks (#)	9 ± 4	10 ± 4	8 ± 4	*0.15*	0.60 ± 0.03	*Small*
Kicks connecting (#)	4 ± 2	5 ± 3	4 ± 2	*0.16*	0.83 ± 0.06	*Moderate*
Post Fight						
RPE (a.u)	16.3 ± 1.5	16.4 ± 1.9	16.2 ± 1.1	*0.44*	0.13 ± 0.00	*Trivial*
Post Lactate (mmol·L^{-1})	12.0 ± 2.8	10.8 ± 3.1	13.1 ± 2.0	*0.16*	-0.89 ± 0.07	*Moderate*

* Statistically significantly different between winning and losing fighters at the $P < 0.05$ level of significance

Conflict of Interest

The authors declare no conflict of interests.

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