Does stature or wingspan length have a positive effect on competitor rankings or attainment of world title bouts in international and elite mixed martial arts?

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Abstract

Background: Whilst most anthropometrical research within sport has focussed on muscle and fat distribution, more studies are measuring the relationship between stature and wingspan, which has been found to be selective criteria in many sports.

Methods: In this study the stature, wingspan and stature-to-wingspan ratio (S:W) was recorded for N = 474 elite and international mixed martial arts (MMA) competitors who appeared in televised bouts over the course of one calendar year. Each weight division was split into three or four ranking groups (RG) depending on division size, as well as into groups depending on if the competitors had won a world title (Ch), competed for a world title (El) or had done neither (In).

Results: One-way ANOVA (≤0.05) found that shorter competitors are ranked higher in flyweight and in the middle in women's straw weight. Independent t-tests (≤0.05) found that shorter competitors also have more chance of winning or competing for a world title in featherweight and flyweight. Independent t-tests (≤0.05) also found a significant difference between males and female for S:W. There was a weak, negative correlation and a moderate, negative correlation between stature and rank in lightweight and light heavyweight respectively and a moderate, negative correlation between S:W and rank in featherweight. There were no other significant differences found.

Discussion: Overall, whilst MMA competitors have a S:W of 1:1.024, due to the paucity of significant differences found, it was determined that anthropometrical measurements cannot be used to predict success in elite and international mixed martial arts.

Key words: MMA; combat sports; ape ratio; stature; success

Introduction

Anthropometry and its effect on an individual's chances of success within high level competition has been studied and documented in several sports (Gabbett, 2000; Mladenovic, 2005; Young et al, 2005; Pieter, 2008) and in many cases has been shown to be a key factor in success, equating to longer careers, greater earning potential and improved chances of selection at an elite level, particularly in sports with specialised skills sets or specific physical requirements (Norton and Olds, 2001). To this end, anthropometry has been used as a tool in talent identification and development across several levels of performance (Gabbett, 2005; Pieter, 2008; Mohamed et al., 2009; Gabbett et al., 2011). Body composition in terms of fat and muscle mass distribution has been more commonly reported in the literature (Alburquerque et al., 2005; Duthie et al, 2006; Adhikari and McNeely, 2015) but generalised whole body measurements are not always found to be indicators of elite performance (Knechtle et al., 2009; Wheeler et al., 2012). Since the 1990's there has been a trend towards researching more detailed anthropometrical measurements such as body segment length and differential growth rates with the aim of finding more reliable performance predictors (Norton and Olds, 1996; Mirwald et al, 2002; Caruso et al, 2009; Stratton and Oliver, 2014).

One particular measurement that has been identified is the so called 'ape index' – a measure of the ratio of an individual's wingspan relative to their stature (Perciavalle et al, 2014). Whilst the average human population is generally perceived to have an 'ape index' of 1:1 (Harbour, 2015), an athlete having a wingspan greater than their stature has been demonstrated to be an advantage and indeed a prerequisite for success in some sports. This is especially the case within basketball, where National Basketball Association (NBA) players are found to have an average stature-to-wingspan ratio of 1:1.064 (Epstein, 2014), whilst elite water polo players have shown significant increases in wingspan length between 1980 and 2008 (Lozovina et al., 2012). The influence of the size of a person's wingspan has also been shown to be a selective criteria in the choice of sports amongst Brazilian adolescents, where those who chose basketball, handball and volleyball had significantly greater wingspans than those who chose football (Silva et al., 2013). Whilst these results indicate that wingspan length has contributed to a form of natural talent selection in each of these sports, this measurement has also been found to have no effect in sport climbing (Mermier et al., 2000) or cricket bowling (Stuelcken et al., 2007; Wormgoor et al., 2010) and is also inferior to other anthropometrical measurements in predicting swimming performance (Perciavalle et al., 2014).

Within mixed martial arts (MMA), Kuhn and Crigger (2013) demonstrated that Ultimate Fighting Championship (UFC) world champions at the time of publication had greater wingspans than the weight divisional mean and in some cases, greater than the mean of some higher weight divisions. This was used to argue that having a greater wingspan is related to success within MMA due to technical advantages it provides in striking and grappling movements. What Kuhn and Crigger (2013) did not discuss was if there exists any differences in the population of MMA competitors as a whole, or whether wingspan length and/or the 'ape ratio' could differentiate between competitors who are close to championship level and those who are not.

Whilst some studies regarding the physical requirements of MMA performance exist (Alm and Yu, 2013; Kirk et al., 2015) there are none that attempt to illustrate how physical properties can influence or predict success. In lieu of an established method of determining an individual's innate physical suitability for MMA, the ratio between a competitor's wingspan and stature could provide an easily obtainable and useful metric, and understanding the relationship between anthropometry and success could allow the development of a more detailed system of talent identification for coaches, training centres and promoters alike. Therefore, it was hypothesised that an MMA competitor with a wingspan greater than their own stature, or those who have a greater stature or wingspan than the divisional mean, will hold a higher ranking than a competitor who does not; and there will be a higher likelihood that an MMA competitor with a wingspan greater than their own stature, or those who have a greater stature or wingspan than the divisional mean will have competed for or won an MMA world title.

Methods

The data of N = 474 participants (age = 29.60 ± 4.12 yrs, mass = 74.26 ± 14.86 kg, stature = 177.49 ± 9 cm) were used for this study from public domain information. The group was made up of N = 425 males and N = 49 females. Ethical approval was granted by the University of Central Lancashire's Research Ethics Sub-Committee, in accordance with the Declaration of Helsinki.

The data in the current study were recorded from the 'Tale of the Tape' measurements reported by event promoters during televised broadcasts of elite and international MMA competitions over the course of one calendar year (16/8/2014 – 16/8/2015 inclusive). The following variables were recorded for each participant: age (yrs), gender, competitive division, mass (kg), stature (cm) and wingspan (cm). Each participant's stature and wingspan was used to calculate their 'ape ratio' (S:W) using the following formula:

S:W = wingspan / stature.

The resulting number is the ratio of the participant's wingspan to their stature (stature always = 1). The mean±SD S:W was calculated for the group as a whole, for each weight division and both genders.

Within each division, the participants were separated into ranking groups (RG) according to their rank on the 17/8/15 as determined by FightMatrix, an independent organisation that uses a computer algorithm to rank professional MMA competitors based on each competitor's levels of success and their opponent's comparative levels of success (FightMatrix, 2015). The reasoning behind using algorithmically generated rankings is that if competitors with greater anthropometrical measurements have a significant advantage over their smaller opponents, then they will also hold a higher ranking due to winning more bouts. The divisions were split into three if there were fewer than 70 participants (RG 1 = the top 33% of ranked participants, RG 2 = the middle 33% of ranked participants and RG 3 = the bottom 33% of ranked participants) and into four if there were more than 70 participants (RG 1 = the top 25% of ranked participants, RG 2 = the second highest 25% of ranked participants, RG 3 = the third highest 25% of ranked participants, RG 4 = the bottom 25% of ranked participants). Where a participant was no longer active on the 17/8/15, such as those who retired from competition during the calendar year, their final ranking was recorded and used.

Whether a participant had won or competed for a world championship title (in any division, at any point in their career) was also recorded to differentiate between participants who could be described as truly elite and those who could not. Within each division those participants who had won a world title were placed in the 'champion' category (Ch), participants who had competed for a world title without winning one were placed in the 'elite' category (El), whilst the remaining participants were placed in the 'international' category (In). Due to the fact that at various points in time, different organisations have been recognised as the accepted 'world title' in various divisions, Table 1 details which titles were recognised in each division for the purposes of this study. Table 1 also details which weight divisions were used in the study and the upper mass limit of each division.

Table 1 – Divisions used and recognised world championship titles

Division	Mass Limit (kg)	Recognised Titles
Heavyweight (HW)	120.5	UFC, Pride FC*
Light Heavyweight (LHW)	93.1	UFC, Pride FC*
Middleweight (MW)	84	UFC, Pride FC*
Welterweight (WW)	77.2	UFC
Lightweight (LW)	70.5	UFC, Pride FC*
Featherweight (FW)	65.9	WEC[#], UFC
Bantamweight (BW)	61.3	WEC[#], UFC
Flyweight (FlW)	56.8	Tachi Palace Fights[Δ], UFC
Women's Bantamweight (WBW)	61.3	Strikeforce[Ʊ] , UFC
Women's Strawweight (WSW)	52.3	Invicta FC[ȸ] , UFC

*Until October 2007 when merged with UFC; # Until December 2010 when merged with UFC; Δ Until December 2011 when holder joined UFC; Ʊ Until January 2013 when merged with UFC; ȸ Until December 2013 when holder joined UFC

Analysis

Normality of data was confirmed using a Shapiro-Wilk test (≥0.05). To determine if anthropometry has any influence on success in MMA, the following statistical analyses were completed for each division for each of the following variables – stature, wingspan and S:W: one way ANOVA between each RG; one way ANOVA between Ch, El and In. One way ANOVA was also calculated between the mean S:W of each division. Effect size (ES) was calculated using omega squared (ω^2) with a small effect ≥ 0.01, a medium effect ≥ 0.06 and a large effect ≥ 0.14.

Independent samples t-tests were calculated to determine any differences in stature, wingspan and S:W between a combined Ch/El group and In for each division and also to ascertain any difference between males and females in terms of S:W for the whole group. ES for the t-tests was calculated using Cohen's d, with SD-Pooled as the denominator and a small $d \geq 0.20$, a moderate $d \geq 0.50$ and a large $d \geq 0.80$.

Finally, Pearson's correlation coefficient was calculated for each division between: stature and rank; wingspan and rank; S:W and rank with a weak $r \leq 0.30$, a moderate $r \leq 0.70$ and a strong $r \geq 0.70$. Significance for each of the named tests was accepted at the ≤0.05 threshold and all procedures were completed using SPSS 22.0 (IBM, New York, USA).

Results

Table 2 details the mean±SD of each variable for the group as a whole and each division. The maximum stature recorded was 212.1 cm, whereas the minimum was 154.9 cm. The maximum wingspan was 214.6 cm and the minimum was 153.7 cm. Amongst the S:W measurements, 1.119 was the maximum and 0.936 was the minimum.

Table 2 - Descriptive statistics by division and for whole group

Division	N	Age (Yrs)	Mass (kg)	Stature (cm)	Wingspan (cm)	S:W
HW	31	33.2 ± 3.8	113.7 ± 5	191 ± 6.5	197 ± 6.7	1.031 ± 0.027
LHW	36	32 ± 4.2	93.4 ± 0.1	186.9 ± 4	193.7 ± 7.6	1.036 ± 0.033
MW	47	31.7 ± 4.7	84.3 ± 0.5	184.7 ± 4.3	189.8 ± 6.4	1.028 ± 0.026
WW	90	29.2 ± 4	77.4 ± 0.3	181.8 ± 4.3	186.6 ± 5.7	1.027 ± 0.024
LW	97	28.9 ± 3.5	70.8 ± 0.8	176.9 ± 4.7	182.1 ± 5.5	1.029 ± 0.028
FW	56	28 ± 3.4	66.2 ± 0.5	174.2 ± 5	178 ± 6.5	1.022 ± 0.027
BW	39	29.7 ± 3.9	61.5 ± 0.7	170.21 ± 3.9	174.1 ± 5.5	1.023 ± 0.028
FlW	29	28.2 ± 3	57.2 ± 0.9	166.1 ± 4.9	167.7 ± 5.3	1.010 ± 0.021
WBW	21	28.8 ± 4.1	61.4 ± 0.3	167.4 ± 5	168.9 ± 6.4	1.009 ± 0.022
WSW	28	27.8 ± 3.8	52.3 ± 0.2	162.2 ± 4.3	163.5 ± 4.3	1.008 ± 0.024
Whole Group	474	29.6 ± 4.1	74.3 ± 14.9	177.49 ± 9	181.9 ± 10.9	1.024 ± 0.027

Table 3 demonstrates that for the most part there were no differences between RG in each division for stature, wingspan or S:W. The only differences found were in FlW where participants of smaller stature actually ranked higher than taller participants (RG1 = 163.3 ± 2.4 cm; RG2 = 166.2 ± 5.8 cm; RG3 = 168.7 ± 4.8 cm) and in WSW where RG2 (159.3 ± 4 cm) had a lesser mean stature than RG1 (163.7 ± 4.2 cm) and RG3 (164 ± 3.1 cm). Whilst ANOVA did not yield significant results, wingspan in FlW did demonstrate moderate ES in favour of RG3 being greater than RG1 and RG2. A similar result was seen for S:W in WSW where RG2 was greater than RG1 and RG3 with a moderate ES.

Table 3 - Differences between RG in each division according to one-way ANOVA (≤0.05) and ω^2

Division	Stature (cm)	Wingspan (cm)	S:W
HW	$F_{(2, 28)}$ = 0.015; p = .985; ω^2 = -0.06	$F_{(2, 28)}$ = 0.014; p = .986; ω^2 = -0.06	$F_{(2, 28)}$ = 0.015; p = .985; ω^2 = -0.09
LHW	$F_{(2, 33)}$ = 1.322; p = .280; ω^2 = 0.02	$F_{(2, 33)}$ = 1.292; p = .288; ω^2 = 0.01	$F_{(2, 33)}$ = 0.531; p = .593; ω^2 < 0.00
MW	$F_{(2, 44)}$ = 0.109; p = .897; ω^2 = -0.03	$F_{(2, 44)}$ = 0.974; p = .386; ω^2 <0.00	$F_{(2, 44)}$ = 1.075; p = .350; ω^2 < 0.00
WW	$F_{(3, 86)}$ = 1.412; p = .245; ω^2 = 0.01	$F_{(3, 86)}$ = 1.412; p = .245; ω^2 = -0.03	$F_{(3, 86)}$ = 1.150; p = .334; ω^2 < 0.00
LW	$F_{(3, 93)}$ = 1.646; p = .184; ω^2 = 0.02	$F_{(3, 93)}$ = 0.290; p = .833; ω^2 = -0.02	$F_{(3, 93)}$ = 0.489; p = .691; ω^2 = -0.04
FW	$F_{(2, 53)}$ = 1.244; p = .297; ω^2 < 0.00	$F_{(2, 53)}$ = 2.023; p = .142; ω^2 = 0.03	$F_{(2, 53)}$ = 1.503; p = .232; ω^2 < 0.00
BW	$F_{(2, 36)}$ = 1.555; p = .225; ω^2 = 0.03	$F_{(2, 36)}$ = 1.223; p = .306; ω^2 = 0.01	$F_{(2, 36)}$ = 0.049; p = .952; ω^2 = -0.07
FlW	**$F_{(2, 26)}$ = 3.454; p = .047; ω^2 = 0.14**	$F_{(2, 26)}$ = 2.785; p = .080; ω^2 = 0.11	$F_{(2, 26)}$ = 0.815; p = .454; ω^2 = 0
WBW	$F_{(2, 19)}$ = 0.567; p = .577; ω^2 = -0.04	$F_{(2, 19)}$ = 0.298; p = .746; ω^2 = -0.07	$F_{(2, 19)}$ = 0.088; p = .916; ω^2 = -0.02
WSW	**$F_{(2, 25)}$ = 4.637; p = .019; ω^2 = 0.2**	$F_{(2, 25)}$ = 0.239; p = .789; ω^2 = -0.05	$F_{(2, 25)}$ = 2.993; p = .068; ω^2 = 0.13

Variables with significant differences are shown in bold.

Table 4 reveals that there were no differences in stature, wingspan or S:W between Ch, El or In for any of the divisions. When comparing Ch/El to In (Table 5), the In group had significantly greater mean stature than the Ch/El group in FW (Ch/El = 169.5 ± 2.4 cm; In = 174.6 ± 5 cm) and in FlW (Ch/El = 163.2 ± 3 cm; In = 167.2 ± 5.1 cm).

Table 4 - Differences between Ch/El/In in each division according to one-way ANOVA (≤0.05) and ω^2

Division	Stature (cm)	Wingspan (cm)	S:W
HW	$F_{(2, 28)}$ = 1.096; p = .348; ω^2 <0.00	$F_{(2, 28)}$ = 2.058; p = .147; ω^2 = 0.06	$F_{(2, 28)}$ = .232; p = .794; ω^2 = -0.09
LHW	$F_{(2, 33)}$ = 1.326; p = .279; ω^2 = 0.02	$F_{(2, 33)}$ = 0.751; p = .480; ω^2 = -0.01	$F_{(2, 33)}$ = 0.094; p = .910; ω^2 = -0.05
MW	$F_{(2, 44)}$ = 0.022; p = .978; ω^2 = -0.04	$F_{(2, 44)}$ = 0.634; p = .535; ω^2 = -0.02	$F_{(2, 44)}$ = 1.196; p = .312; ω^2 < 0.00
WW	$F_{(2, 87)}$ = 0.959; p = .387; ω^2 < 0.00	$F_{(2, 87)}$ = 0.790; p = .457; ω^2 < 0.00	$F_{(2, 87)}$ = 0.273; p = .762; ω^2 = - 0.04
LW	$F_{(2, 94)}$ = 0.808; p = .449; ω^2 < 0.00	$F_{(2, 94)}$ = 1.008; p = .369; ω^2 < 0.00	$F_{(2, 94)}$ = 0.641; p = .529; ω^2 < 0.00
FW	$F_{(2, 53)}$ = 2.039; p = .140; ω^2 = 0.04	$F_{(2, 53)}$ = 0.621; p = .541; ω^2 = -0.01	$F_{(2, 53)}$ = 0.361; p = .698; ω^2 =- 0.05
BW	$F_{(2, 36)}$ = 0.410; p = .666; ω^2 = -0.03	$F_{(2, 36)}$ = 1.034; p = .366; ω^2 < 0.00	$F_{(2, 36)}$ = 0.397; p = .675; ω^2 = -0.07
FlW	$F_{(2, 26)}$ = 2.064; p = .147; ω^2 = 0.07	$F_{(2, 26)}$ = 0.688; p = .512; ω^2 = -0.02	$F_{(2, 26)}$ = 0.528; p = .596; ω^2 = 0
WBW	$F_{(2, 19)}$ = 0.044; p = .957; ω^2 = -0.1	$F_{(2, 19)}$ = 0.364; p = .700; ω^2 = -0.06	$F_{(2, 19)}$ = 0.585; p = .567; ω^2 = -0.18
WSW	$F_{(2, 25)}$ = 0.226; p = .799; ω^2 = -0.05	$F_{(2, 25)}$ = 0.231; p = .795; ω^2 = -0.06	$F_{(2, 25)}$ = 0.000; p = 1.000; ω^2 = -0.13

Table 5 – Differences between Ch/El and In according to independent samples t-test (≤0.05) and Cohen's *d*

Division	Stature (cm)	Wingspan (cm)	S:W
HW	$t_{(29)} = -1.128$; p = .269; *d* = -0.47	$t_{(29)} = -1.563$; p = .129; *d* = -0.62	$t_{(29)} = -0.584$; p = .564; *d* = -0.24
LHW	$t_{(34)} = 0.808$; p = .424; *d* = 0.30	$t_{(34)} = 0.635$; p = .530; *d* = 0.22	$t_{(34)} = 0.203$; p = .840; *d* = 0.06
MW	$t_{(45)} = 0.003$; p = .998; *d* = 0	$t_{(45)} = 1.123$; p = .268; *d* = 0.49	$t_{(45)} = 1.494$; p = .142; *d* = 0.64
WW	$t_{(88)} = -0.257$; p = .798; *d* = -0.08	$t_{(88)} = -0.740$; p = .461; *d* = -0.24	$t_{(88)} = -0.743$; p = .459; *d* = -0.27
LW	$t_{(95)} = -0.974$; p = .333; *d* = -0.4	$t_{(95)} = -0.073$; p = .942; *d* = -0.02	$t_{(95)} = 0.838$; p = .404; *d* = 0.05
FW	**$t_{(54)} = -2.021$; p = .048; *d* = -1.3**	$t_{(54)} = -1.106$; p = .273; *d* = -0.6	$t_{(54)} = 0.629$; p = .532; *d* = 0.37
BW	$t_{(37)} = -0.847$; p = .403; *d* = -0.39	$t_{(37)} = -1.317$; p = .196; *d* = -0.6	$t_{(37)} = -0.803$; p = .427; *d* = -0.35
FlW	**$t_{(27)} = -2.056$; p = .05; *d* = -0.95**	$t_{(27)} = -1.170$; p = .252; *d* = -0.56	$t_{(27)} = 1.047$; p = .304; *d* = 0.41
WBW	$t_{(19)} = -0.132$; p = .896; *d* = -0.08	$t_{(19)} = -0.583$; p = .567; *d* = -0.34	$t_{(19)} = -0.807$; p = .430; *d* = -0.04
WSW	$t_{(26)} = 0.193$; p = .848; *d* = 0.09	$t_{(26)} = 0.229$; p = .821; *d* = 0.1	$t_{(26)} = -0.004$; p = .997; *d* = 0

Variables with significant differences are shown in bold.

Table 6 demonstrates that LHW has a moderate negative correlation between stature and rank, whilst LW displayed a weak negative correlation between stature and rank and FW had a moderate, negative correlation between S:W and rank.

Table 6 - Pearson's correlation coefficients (≤0.05) between variables and rank by division

Division	Stature (cm)	Wingspan (cm)	S:W
HW	$r_{(29)} = .054$; p = .772	$r_{(29)} = -.093$; p = .618	$r_{(29)} = -.175$; p = .346
LHW	**$r_{(34)} = -.362$; p = .030**	$r_{(34)} = -.165$; p = .337	$r_{(34)} = .049$; p = .776
MW	$r_{(45)} = -.108$; p = .469	$r_{(45)} = -.229$; p = .122	$r_{(45)} = -.203$; p = .171
WW	$r_{(88)} = .096$; p = .367	$r_{(88)} = -.053$; p = .622	$r_{(88)} = -.161$; p = .129
LW	**$r_{(95)} = -.242$; p = .017**	$r_{(95)} = -.042$; p = .682	$r_{(95)} = .191$; p = .061
FW	$r_{(54)} = -.047$; p = .730	$r_{(54)} = -.253$; p = .060	**$r_{(54)} = -.305$; p = .022**
BW	$r_{(37)} = .232$; p = .155	$r_{(37)} = .220$; p = .178	$r_{(37)} = .055$; p = .740
FlW	$r_{(27)} = .328$; p = .083	$r_{(27)} = .322$; p = .089	$r_{(27)} = .006$; p = .974
WBW	$r_{(19)} = -.085$; p = .713	$r_{(19)} = -.132$; p = .570	$r_{(19)} = -.110$; p = .636
WSW	$r_{(26)} = -.046$; p = .814	$r_{(26)} = .064$; p = .746	$r_{(26)} = .136$; p = .491

Variables with significant correlations to rank are shown in bold.

Amongst the whole group, one-way ANOVA found a general trend whereby the lower the mass limit of the division, the smaller the mean S:W with a small effect ($F_{(9, 464)} = 4.606$; $p < .001$; $\omega^2 = 0.05$). It was also found that female participants (S:W = 1.008 ± 0.022) have a significantly smaller S:W than male participants (S:W = 1.026 ± 0.027) ($t_{(472)} = 4.476$; $p < .001$; $d = 0.22$).

Discussion

The aim of this study was to determine whether stature, wingspan or the S:W metric had any relation to success in MMA. In light of the results presented in this paper, it is necessary to reject this hypothesis and state that a competitor having greater stature, wingspan or S:W does not equate to more success in terms of higher ranking or title bouts. Indeed it was found that it appears to be advantageous to be shorter in the FW and FlW divisions if a competitor wants to challenge for a world title. This could be caused by a potential increase in speed and reaction time on the part of the shorter competitors giving them a natural advantage in MMA, but this does not explain why this is not seen in BW which sits between the FW and FlW. Why would a speed advantage be demonstrated in FW but not in the lighter weight division of BW?

Similarly, whilst these is a moderate correlation between S:W and rank in FW, this appears to be influenced more by shorter competitors having more success than any effect of the S:W ratio. The correlations found between stature and rank in LHW and LW are also inconclusive as they are not strong correlations, in fact they were only .005 - .062 above the threshold between weak and moderate and in addition, the r for LHW was found using a relatively small sample size so is lacking in power. Therefore it would be unwise to make any statement about the positive effect of anthropometry on MMA performance from these outcomes.

Whilst there were differences in stature recorded between RG in WSW, this was found to be because RG2 had smaller stature than both RG1 and RG3, meaning that being taller in this division can be viewed as either a blessing or a curse as taller competitors have as much chance of being successful as they do of being unsuccessful. This study cannot explain why this phenomenon has occurred and it may be that this may change over time as the available sample grows.

The trend of the larger divisions having significantly greater S:W and male's demonstrating significantly greater S:W than females fits the general pattern of anthropometric differences between genders (Bjelica et al., 2012). Whilst it seems obvious that taller people would have greater wingspans, these results show that the larger mass participants also displayed significantly greater S:W. Having a wingspan in excess of a person's stature has been shown to be a selective criteria in many sports, as has stature itself (Norton and Olds, 2001), although this may not be inferred from the current study without comparing the results to the non-MMA population. All that may be stated is that as MMA competitor's mass increases, so too does the difference between their stature and wingspan. Could this be caused by the populations of the heavier weight divisions being recruited from other sports where greater wingspans give a natural advantage (such as American football and basketball) or is there another reason behind this pattern? This can only be answered through further research.

Whilst there are few significant results, there are several results across all variables which demonstrate negative ES, meaning that in many cases participants with smaller stature, wingspan or S:W are ranked higher or have competed for/won world titles. This can be interpreted to show that whilst being comparatively smaller does not guarantee success, there are instances where more successful competitors are on average shorter or have smaller wingspans.

This means that there must be something else which has a greater effect on the success rates of an MMA competitor than having larger natural body measurements, such as skill base, timing, strength, aerobic endurance, etc. This leads to an interesting question: if these anthropometric measurements have little to no effect, why do MMA promoters report the competitor's wingspan and why can some spectators place so much reliance on this seemingly irrelevant statistic? The answer may be that many of MMA's protocols and traditions are taken directly from boxing (Gentry, 2005), a sport where a competitor with a longer reach is perceived to have an advantage in controlling the distance and being able to strike their opponent easier without getting struck themselves. This could also be the case in MMA during the striking portions of a bout, however, it has been shown that MMA competitors spend relatively large amounts of time engaged in grappling movements or in a clinch, and that it is these phases of combat that most contribute to a winning performance (Del Vecchio et al., 2011; Kirk et al., 2015). This seems to negate any advantage that a competitor with a longer wingspan would have, as a smaller opponent can simply engage them in a clinch or a grapple, making any differences in wingspan and/or S:W largely meaningless. This outcome has been mirrored in the grappling sport of wrestling (Demirkan et al., 2015).

In conclusion, neither wingspan or S:W can be used as a performance predictor in elite or international MMA, although having a taller stature may be a limiting factor in some divisions. There could be an argument that stature, wingspan or S:W could be the difference between two individual competitors in a single bout, however, this does not appear to translate to long term success in the divisional rankings or attainment of a title bout. Whilst there is no reason to not report the respective statures and wingspans of competitors prior to a bout, coaches and researchers would be advised to develop a more suitable anthropometric measurement on which to predict success, or to discover other sport specific methods of identifying talent.

Limitations

As the data used in this study was those reported by the promoters during televised MMA events, it is not known how or when these measurements were taken. This could lead to some inaccuracies in the measurements; however, given the conclusive nature of these results, it can be argued that any alterations to some of the recorded measurements would have little impact on the overall picture that has emerged.

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