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# CAPACITY AND CONFIDENCE

## WHAT CAN BE GLEANED FROM THE LINK BETWEEN PERCEIVED AND ACTUAL PHYSICAL ABILITY IN BRAZILIAN JIU-JITSU PRACTITIONERS?

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### ABSTRACT

Brazilian jiu-jitsu (BJJ) is one of the most popular modern iterations of grappling-based combat sports. Progression in BJJ involves persistence in the face of repeated defeat in training, which may require certain psychological characteristics, or at least the ability to cultivate them. Although BJJ is highly technical, performance is also influenced by physical fitness, which in turn may be associated with the practitioners' psychological approach and adherence to the sport. Through exploratory data analysis, this paper sought to elucidate the relationship between perceived and actual physical ability in BJJ practitioners. Both aerobic and muscular endurance appeared to be associated with perceived physical ability independent of factors such as rank and training experience. Conversely, maximal strength did not correlate with this construct. These findings indicate that physical fitness may be conducive to both BJJ performance and adherence through its relationship with self-efficacy. Since self-efficacy is concerned with belief in the ability to produce a subjectively desired outcome and does not necessarily reflect actual skill, the potential psychological advantage of physical fitness is likely applicable to practitioners at all levels of competence.

## INTRODUCTION

Grappling-based combat sports, such as wrestling and jujutsu, have existed for centuries. Among its modern derivatives, Brazilian jiu-jitsu (BJJ) has emerged as one of the most popular styles, both as a recreational and competitive practice. It is generally considered to be a challenging art to master, with a constantly growing number of rulesets and strategies, techniques and technical variations, as well as a notable emphasis on simulated fighting in training. These aspects have implications for adherence, with the attrition rate being described as very high [Canaria 2016], particularly among the lower ranks [Huni 2019]. Many of the potential causes of attrition, such as technical and physical difficulties, external performance scrutiny by coaches and peers, and being repeatedly forced to concede defeat during simulated combat against a resisting opponent, especially at the beginning of one's learning trajectory, are inherently related to BJJ. Thus, insight into the psychology of active practitioners and their motivational dynamics may reveal characteristics that can be targeted to improve adherence, as well as other aspects of progression and performance [Øvretveit et al. 2018].

The quest to understand the psychological underpinnings of motivation in sports and other performance settings has led to an abundance of cognitive theories. Among the most prominent concepts is Bandura's [1977] self-efficacy, which has served as a basis for analyses and predictions of behavioral mechanisms in various performance settings, including challenging and unpleasant ones. It can be briefly described as the judgment of personal capability, which distinguishes it from similar terms such as self-esteem, a term that pertains more to feelings of self-worth [Bandura 1997]. The level of self-efficacy has been shown to correspond to the degree of performance, as well as being inversely related to emotional arousal [Bandura 1982], with incremental goal setting being crucial to its development [Bandura and Schunk 1981]. Interestingly, changes in self-efficacy may be mediated by changes in physical fitness, such as improved aerobic endurance [McAuley et al. 2000]. This suggests a positive feedback loop in which self-efficacy beliefs may cause individuals to engage in activities that lead to further development of these perceptions.

Self-efficacy tends to vary across domains, and the inherent limitations of global self-efficacy measures have resulted in various domain-specific tests [Bandura 1986]. One of these is the physical self-efficacy scale by Ryckman and colleagues [1982], which measures physical self-concept. Applications of this instrument indicate that those who perceive themselves as being physically skillful not only have higher self-esteem and strong internal locus of control but also may outperform those with lower physical self-efficacy in motor tasks [Ryckman et al. 1982]. Since self-efficacy is the belief in personal capability independent of actual

capability, cultivating self-efficacy may directly influence behavior and performance in sports at a given level of capacity or skill [Feltz 1988]. The notion that mindset not only can improve performance but fundamentally alter the way athletes approach and adhere to their sport is compelling, perhaps particularly so in the context of what is generally considered mentally challenging and often discouraging activities, such as full-contact combat sports.

Traditionally, the physiological and psychological attributes of athletes are studied separately, although some overlap is not uncommon. It could be argued that this somewhat reductionistic approach, albeit often both necessary and advantageous, leaves the relationship between observations from the two disciplines relatively unexplored. Historically, constructs quantifying the experience of martial arts practitioners in training has been lacking [Sandford et al. 2020]. Recent applications of non-specific, well-established instruments indicate that BJJ practitioners are likely to adopt goals of mastery [Øvretveit et al. 2018] and that this in turn may lead to a greater training effort [Øvretveit et al. 2019]. The latter observation suggests that mindset may influence training adaptations, thus hinting at a potential link between physiological and psychological attributes among these practitioners. The present paper sought to further investigate such a link through exploratory analysis of data from recent investigations of physiological [Øvretveit 2018b] and psychological [Øvretveit et al. 2018] characteristics of BJJ practitioners. The main aim was to assess the relationship between how these practitioners perceive their physical ability and their actual physical ability, as determined by standardized laboratory measurements of various parameters of strength, endurance, and body composition. To the best of the author's knowledge, no other study to date has interrogated these associations in this population.

## MATERIALS AND METHODS

### Participants

The study sample consisted of 42 male BJJ practitioners (age:  $31.9 \pm 6.2$  years; height:  $181.9 \pm 7.2$  cm; body mass:  $85.7 \pm 10.6$  kg; body fat:  $12.9 \pm 5.3$  %) with  $5.5 \pm 3.7$  years of training experience and  $7.8 \pm 3.4$  hours of weekly BJJ training at the time of data collection. To ensure a certain level of experience, practitioners with < two years of consistent training or < one year of training and no competition experience were ineligible to participate. To construct a pooled dataset, anthropometric and physical performance data [Øvretveit 2018b] were linked with psychological data [Øvretveit et al. 2018] from the same cohort using anonymous subject identifiers. This data was then reanalyzed for the purpose of exploring associations between perceived and actual physical performance. The data collection protocol was reviewed by the local ethics committee, registered with the Norwegian Centre for Research Data, and carried out in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

### Perceived physical ability measurement

Perception of physical ability was measured with the Perceived Physical Ability (PPA) subscale of the Physical Self-Efficacy Scale developed by Ryckman et al. [1982] in its original language. The PPA scale is composed of ten items that cover perceptions of attributes such as strength, speed, and agility. The participants scored each item on a scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*), giving a possible range of 10 to 60. The PPA scale has previously been shown to be reliable in various study populations [Ryckman et al. 1982; McAuley and Gill 1983; McAuley et al. 2000].

### Physical performance measurements

The participants underwent same-day supervised fitness testing in an exercise laboratory [Øvretveit 2018b]. Body mass and composition were determined with segmental multifrequency bioelectrical impedance analysis (MC-980-MA, Tanita Corp., Tokyo, Japan). Maximal oxygen uptake ( $\dot{V}O_{2\max}$ ) was assessed with an incremental cardiopulmonary exercise test (CPET) on a motorized treadmill (PPS 55 Med, Woodway GmbH, Weil am Rhein, Germany) at a 3° inclination. Oxygen uptake ( $\dot{V}O_2$ ) was monitored throughout the test with a calibrated respiratory analysis system (Vmax Spectra 229d, SensorMedics, Yorba Linda, CA, USA). The highest 30-second average  $\dot{V}O_2$  was calculated and accepted as  $\dot{V}O_{2\max}$  if the participant had met at least two of the following criteria: a  $\dot{V}O_2$  plateau, being  $\leq 5$  beats within maximal heart rate if this was known, a respiratory exchange ratio of  $\geq 1.1$ , and/or a blood

lactate concentration of  $\geq 8$  mM. Following the CPET, each participant performed one-repetition maximum (1RM) strength tests in the parallel squat and paused bench press. A progressive loading protocol towards failure was applied to reach 1RM within five attempts in both exercises. Additionally, one set of as many repetitions as possible of pronated-grip pull-ups was performed as a measurement of muscular endurance.

### Statistical analysis

Statistical analyses were performed using IBM SPSS version 25 (Chicago, IL, USA). Graphics were made using GraphPad Prism version 6 (San Diego, CA, USA). Data normality was assessed with the Shapiro-Wilk test. The reliability of the PPA measure was tested with Cronbach's [1951]  $\alpha$ . To evaluate relationships between PPA and physical performance and other characteristics, Spearman rank-order correlation coefficients were calculated. The independent samples *t*-test was used to compare PPA between practitioners based on whether they competed, instructed, or incorporated additional strength and conditioning training, as well as their style preference and previous martial art experience. Statistical significance was accepted at  $p < 0.05$  for all observations.

## RESULTS

Participants who did not rate all items on the PPA questionnaire ( $n = 3$ ), or none due to language issues ( $n = 1$ ), were excluded from all analyses. Preexisting injury prevented performance measurements for some; however, only one participant was unable to undergo any form of maximal exercise testing. There was no apparent association between PPA and age, rank, experience, or training volume ( $p > 0.05$ ). Similarly, PPA did not correlate with anthropometric measurements such as height, body mass, body fat mass, or lean mass ( $p > 0.05$ ). A significant relationship between PPA and  $\dot{V}O_{2\max}$  was detected (table 1; figure 1). This relationship also held true for allometrically scaled ( $r_s = 0.33$ ,  $p < 0.05$ ) and population-relative  $\dot{V}O_{2\max}$  ( $r_s = 0.40$ ,  $p < 0.05$ ). Although no association with maximal strength was found, PPA correlated with muscular endurance (table 1; figure 2). Similar to  $\dot{V}O_{2\max}$ , the relationship between PPA and pull-ups remained significant when dividing repetitions by body mass ( $r_s = 0.25$ ,  $p < 0.05$ ) and tended to also be significant for allometrically scaled pull-up performance ( $r_s = 0.23$ ,  $p = 0.056$ ). No difference in PPA was found between those who competed or instructed compared to those who did not ( $p > 0.05$ ). Similarly, those who regularly trained strength and/or conditioning outside of BJJ did not differ in PPA ( $p > 0.05$ ). Lastly, no effect of style preference, *i.e.*, training with or without the gi, nor previous martial art experience was observed ( $p > 0.05$ ).

Table 1:  
Perceived physical ability and  
physical performance correlation  
matrix

	Mean	± SD	1	2	3	4	5	6
<b>1. PPA</b>	40.1	± 5.2						
<b>2. Training experience (y)</b>	5.3	± 3.8	-0.17					
<b>3. Training volume (h'week<sup>-1</sup>)</b>	7.7	± 3.3	0.19	-0.33*				
<b>4. <math>\dot{V}O_2</math> max (mL'kg<sup>-1</sup>min<sup>-1</sup>)</b>	50.6	± 4.6	0.35*	-0.13	0.26			
<b>5. Squat (kg)</b>	113.2	± 20.4	0.14	-0.26	0.03	-0.07		
<b>6. Bench press (kg)</b>	87.6	± 16.5	-0.07	-0.23	0.01	-0.20	0.53**	
<b>7. Pull-ups (n)</b>	9	± 4	0.34*	-0.19	0.17	0.46**	0.07	0.23

SD, standard deviation; PPA, perceived physical ability;  $\dot{V}O_2$  max, maximal oxygen uptake; \*  $p < 0.05$ , \*\*  $p < 0.01$ .

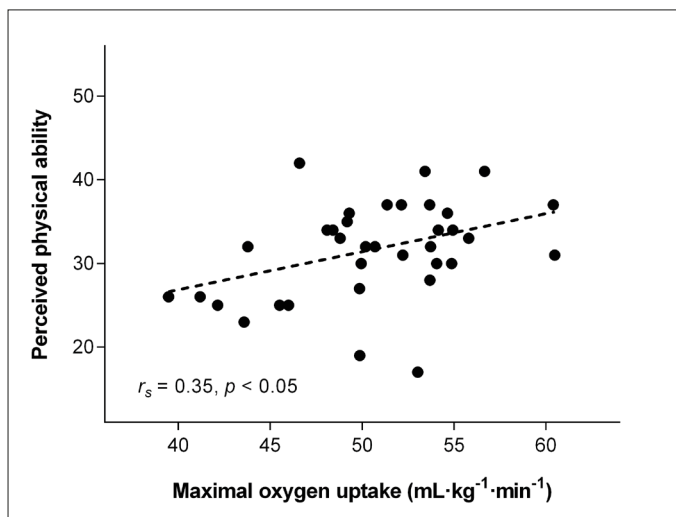


Figure 1:  
The relationship between perceived physical  
ability and maximal oxygen uptake

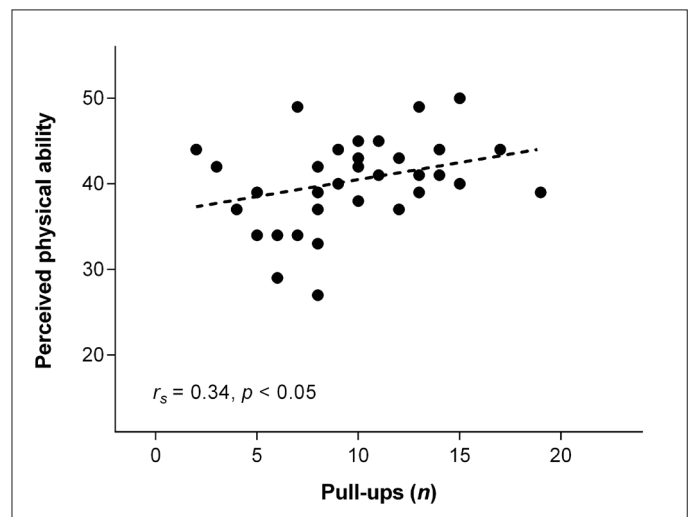


Figure 2:  
The relationship between perceived physical  
ability and muscular endurance

The PPA scale had a Cronbach's  $\alpha$  of 0.51, indicating poor internal consistency of this instrument in the present study sample. The most problematic items were #3 (*'My physique is rather strong'*) and #9 (*'I have a strong grip'*), both of which had negative corrected item-total correlations despite being ordered correctly. Removing these items resulted in an acceptable  $\alpha$  of 0.71. Furthermore, both the strength and significance of the association between the full PPA scale and  $\dot{V}O_2$  max persisted with the modified scale, with a tendency for the association with pull-ups ( $p = 0.065$ ).

## DISCUSSION

Confidence is an important factor for not only performance but also adherence in sport. The self-efficacy concept pertains to domain-specific belief in personal capability, which in turn can influence behavior through mechanisms such as persistence, intensity, and arousal. In its original theoretical outline, Bandura stated that 'persistence in activities that are subjectively threatening but in fact relatively safe produces, through experiences of mastery, further enhancement of self-efficacy and corresponding reductions in defensive behavior' [Bandura 1977: 191]. The beliefs a BJJ practitioner holds about his or her ability are presumably derived primarily from experiences on the training mat, performing technical drills, or engaging in simulated combat; situations that can often appear to be subjectively threatening yet are objectively relatively safe.

In general, involvement in martial arts may lead to positive psychological outcomes [Vertonghen and Theeboom 2010]. In BJJ specifically, the notion that persistence leads to experiences of mastery is supported by previous observations that mastery goals are prevalent among its practitioners [Øvretveit et al. 2018], something that also holds true for other grappling-based combat sports, such as judo [Gernigon and le Bars 2000]. As these observations are made in active practitioners, i.e., those who have and continue to persist, one could argue that they are unsurprising – that mastery goals are to be expected among active combat sports practitioners because they have endured subjectively threatening situations. And since these situations are intrinsically related to BJJ, practitioners must either adapt, suffer, or quit.

The main discoveries of the present analysis were the apparent associations between  $\dot{V}O_2$ max, muscular endurance, and perceptions of physical ability. As the gold standard measurement of cardiorespiratory fitness,  $\dot{V}O_2$ max is one of the most common and informative metrics in sports. In BJJ, which is largely an aerobic sport, it has been associated with less fatigue during simulated combat [Øvretveit 2018a]. Additionally,

the fatigue resistance offered by a high  $\dot{V}O_2$ max may also be beneficial to the quality of technical training and recovery between matches in tournaments.

Despite this,  $\dot{V}O_2$ max appears to be quite similar across ranks [Andreato et al. 2017], which could be due to a ceiling effect of sport-specific BJJ training on the cardiovascular system [Øvretveit 2018b]. The presence of a ceiling effect is supported by training interventions that incorporate non-sport-specific high-intensity interval training alongside regular BJJ training, which has shown to rapidly improve  $\dot{V}O_2$ max compared to BJJ training alone [Øvretveit 2019]. As  $\dot{V}O_2$ max reflects the maximal rate of oxygen consumption, it cannot be further improved by changes in mindset, e.g., increasing the level of self-efficacy. This is in contrast to tasks involving motor skills, which can be influenced by self-efficacy beliefs, such as PPA [Ryckman et al. 1982]. If the observed relationship between  $\dot{V}O_2$ max and PPA in BJJ practitioners is valid, the direction, then, is likely to be from the former to the latter; aerobic endurance may have a nontrivial impact on grappling performance and/or the training experience, independent of technical skill, which in turn influences PPA through mechanisms such as subjective experiences of mastery on the mat.

### Fatigue makes cowards of us all

To better understand the role of  $\dot{V}O_2$ max in BJJ, it is important to distinguish it from another (and in this sport perhaps more emphasized) aspect of endurance: work economy. Together with  $\dot{V}O_2$ max and lactate threshold, work economy, or efficiency, is considered a fundamental performance determinant in endurance sports [Joyner and Coyle 2008]. Granted, although the metabolic demand of BJJ is primarily aerobic in nature, it is not a traditional endurance sport. Thus, as opposed to cycling, cross-country skiing, rowing, or middle-to-long distance running, the traditional endurance components are less crucial. However, fatigue is an inescapable fact of all physical activity and one that is often simply caused by a transient lack of oxygen.

The technical development in BJJ has in many ways been characterized by the aim of minimizing the reliance on physical attributes [Gracie and Danaher 2003]. For instance, an athlete in top position will often try to make his opponent carry his weight, while the bottom athlete will counter this by placing his limbs in ways that create space and displaces pressure by relying on angles and bone structure rather than muscular force. This makes the goal of becoming more technically proficient, rather than just fitter, quite rational. Technical development is, of course, crucial to progressing as a practitioner and arguably more important than fitness in terms of performance. Moreover, technical proficiency is closely related to sport-specific endurance through its impact on the oxygen cost of exercise: a high-level practitioner

is typically able to perform a technique with lower metabolic cost compared to lower-level practitioners.

Technique directly impacts sport-specific endurance, because as motor learning increases metabolic cost decreases [Huang et al. 2012]. In other words, when a practitioner becomes more technically proficient, metabolic expenditure and thus the energy requirement of grappling techniques is reduced. However, as BJJ involves a resisting opponent, the cost of movement is not entirely up to the practitioner. Although technical proficiency may contribute to a reduction in the dependence on physical attributes,  $\dot{V}O_{2max}$  becomes increasingly important when techniques go from cheap to expensive, which can happen for a multitude of reasons. And research shows that it will happen both in training and competition [Andreato et al. 2016] and that a high  $\dot{V}O_{2max}$  allows for aerobic metabolism to occur at higher intensities, which can sustain performance for longer and/or repeated periods [Øvretveit 2018a]. The distinction between fitness- and technique-mediated endurance has previously been discussed among prominent figures in the sport, such as renowned coach John Danaher [2016]:

**When I watch beginners train together the single most common method of defeat is fatigue. Beginners typically lack the skills required to gain a victory through the purity of their technique and thus usually one of them is worn down to a state where they cannot maintain resistance and they succumb. The problem usually gets better with time, but remains to some degree throughout our jiu jitsu lives. Everyone has to confront and overcome this problem if they wish to remain in the sport. The problem is, most people attack the problem in the wrong way. The overwhelming majority of students deal with the problem by trying to bring about changes in their bodies – they make efforts to make themselves stronger and fitter. This is good and desirable and yes – it definitely helps to some degree.**

Here, a separation between physiological and technical endurance is clearly acknowledged. Danaher [2016] continues:

**However, whatever endurance improvements you make from strength and fitness increases are minuscule compared with those that come from increased mechanical efficiency in technique and pace control during a match. It will take a lot of time and training to increase your maximum bench press by just 10% – but that increase will be barely perceptible to your opponent in sparring. However, small improvements in the placement of lever and fulcrum as you apply technique throughout a match will be immediately felt by an opponent as increased force and by you as energy saving – if this is combined with pace control you will find dramatic improvements in grappling endurance without any significant**

**changes in your physiology. [...] If you want dramatic improvements – don't look to change your body, rather, look to change your technical insight and pace control.**

Coming from the perspective of an instructor, Danaher unsurprisingly favors technical rather than physiological development as an energy management strategy. This largely makes sense from a physiological perspective as well. In BJJ, the potential for improvement by making the proverbial machine more efficient is greater than increasing the size of its engine. The world's greatest endurance athlete would stand no chance against a BJJ practitioner with even a fairly basic skillset in a match with no time limit. Interestingly, Danaher also points at something that may underpin the PPA- $\dot{V}O_{2max}$  relationship in BJJ: fatigue is a common way to lose, particularly among beginners. Thus, as long as skill and strategy are either lacking, as in beginners, or matched, as in competent practitioners who face an equally competent opponent, physical capacity becomes a comparably sharp weapon.

The fact that neither PPA [Øvretveit et al. 2018] nor  $\dot{V}O_{2max}$  [Øvretveit 2018b; Andreato et al. 2017] appear to be associated with BJJ rank indicates that, assuming the relationship is valid,  $\dot{V}O_{2max}$  can increase PPA through subjective beliefs in the ability to perform at any level of practice. In other words, capacity may improve confidence independent of sport-specific competence. This is consistent with the self-efficacy concept, which is mainly concerned with belief in the application and not the actual level of skill [Feltz 1988]. For the lower belts, this may be defending a chokehold longer, or just surviving five minutes of grappling at all. For the higher belts, it could mean being able to go hard every round against opponents that try their best to win. As long as the outcome is subjective, normative performance, e.g., who dominated the sparring round, is less important.

A common analogy to BJJ training is that of drowning [Harris 2012; Williams 2020]. Since oxygen is often restricted in more ways than one, drowning is an apt description of what it can feel like to be controlled by a superior practitioner, which is something every single BJJ practitioner has felt. It is an example of a 'threatening, yet safe' situation that is highlighted as a key ingredient in the development of self-efficacy, as well as BJJ proficiency. And in these situations,  $\dot{V}O_{2max}$  has the potential to make a practitioner more resistant to the figurative, and sometimes not too far from literal, drowning, because it reflects the ability to transport oxygen from the atmosphere to the mitochondria. By more efficiently supplying the cells of the working muscles with oxygen, an aerobically fit practitioner will likely survive longer in physiologically taxing conditions, which may or may not involve someone applying pressure to his or her trachea or carotid arteries. Although the energy demands of BJJ combat vary considerably, everybody needs oxygen at some point.

### Strength is relative

Equally as strong as the PPA- $\dot{V}O_2$ max relationship was that between PPA and muscular endurance, quantified here by pull-up performance. These two attributes were also associated with each other, which was unsurprising as they both are influenced by body mass. Although the relationship between physical performance and body mass is not necessarily straightforward [Åstrand and Rodahl 1986],  $\dot{V}O_2$ max is typically expressed as the maximal oxygen uptake relative to body mass, while body mass provides the sole resistance in pull-ups. Interestingly, PPA was not related to neither total body mass nor body fat mass, similar to previous findings in physically active cohorts [Morano et al. 2011]. Actual performance ability, then, might be more important to the practitioner's perceptions than weight, and by conceivable extension, looks. Although pulling is a common movement in BJJ, the exact pull-up pattern is rarely seen. Pull-up performance may instead reflect a general strength-to-weight ratio which, in a weight class sport such as BJJ, offers a performance advantage.

Notably, neither maximal squat nor bench press strength was associated with PPA. There is no question that maximal strength can be beneficial to grappling performance and thus a potential source of confidence for the practitioners. Indeed, evidence suggests that stronger grapplers are better grapplers [Chaabene et al. 2017; Franchini et al. 2011; Silva 2012]. In BJJ specifically, more skilled practitioners have repeatedly demonstrated better performance in the bench press [da Silva et al. 2015; Marinho et al. 2016]. However, performance in these exercises typically favors larger individuals and the PPA scale may not fully capture the sport-specific benefits of being big and strong, but rather be more biased towards smaller and faster individuals, with statements involving agility, grace, and speed outnumbering those on strength.

The notion that physical fitness can mediate changes in self-efficacy is not new [McAuley et al. 2000], and the significance of physical attributes such as strength and endurance in BJJ, particularly in a competitive setting, is fairly clear. Parenthetically, as opposed to strength and conditioning training that leads to improved physical fitness, skill training, e.g., technical BJJ drilling, may actually have no meaningful effect on self-esteem [Spence et al. 2005]. Although the impact of being fit is hard to quantify, because the sport is not about being the strongest or fastest, it still matters, often a lot. Although BJJ does not tend to produce highly fit athletes [Øvretveit 2018b; Andreato et al. 2017], the likely cause is a lack of sufficient stimuli to produce adaptations above a certain level and not a lack of importance of fitness in the sport. And, assuming the relationships observed in the present study are valid, physical fitness may protect against attrition. In the context of BJJ and self-efficacy, this boils down to the notion that fitter athletes have greater belief in their ability to apply their skills, however

poor or great they may be, in BJJ. Repeated application of said skills will inevitably lead to improvements which in turn will reinforce their beliefs. Conversely, unfit practitioners are physiologically more likely to crumble and quit.

### LIMITATIONS

Although this exploratory analysis may offer several potential hypotheses for future research, they are not without limitations. The analyses relied on combining data from cross-sectional studies that were not specifically designed to tease out associations between perceived and actual physical ability. The study population was smaller than what is typical in sport psychology research, including studies on physical self-efficacy. Additionally, the reliability of the PPA scale was poor, with two items even demonstrating negative item-total correlations. Although a reanalysis with a modified instrument with acceptable reliability generally supported the initial observations, the poor reliability is an issue, and caution should be taken when assessing PPA in this population. A potential cause for the reliability issues could be that the scale was not translated, but administered in its original language, English. This was done because the study population consisted of practitioners from various countries, most of which spoke English as their second language and some as their first. Considering the challenges associated with novel translations of a validated instrument, this was likely the best solution for an international study sample but may have influenced outcomes. Albeit interesting and perhaps logical, the relationships between PPA and aerobic and muscular endurance are speculative. Although the present study hinted towards such associations, the findings are still inconclusive. Additional studies specifically designed to tease out this and other potential relationships between perceived and actual physical ability in BJJ practitioners are encouraged.

### CONCLUSIONS

The present observations suggest that aerobic and muscular endurance may be associated with perceived physical ability in BJJ practitioners. The physical demands and structure of the sport lend support to the validity of these relationships. Although it is plausible that practitioners with a high baseline level of fitness are more likely to experience mastery on the mat, an emphasis on technical rather than physiological development is more conducive to the progression of actual, sport-specific ability. The interaction between physical fitness and self-efficacy in combat sports practitioners, both in terms of performance and adherence, is compelling yet remains speculative.

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