The MMA Training Bible's Guide to Performance Testing in Mixed Martial Arts

By. Dr. Jason Gillis

About The MMA Training Bible

The MMA Training Bible, created by Dr. Jason Gillis, aims to provide fighters and coaches in mixed martial arts and other combat sports with evidence-based training advice.

Dr. Jason Gillis is an Assistant Professor working in the Human Performance Lab at Salem State University. Here, he engages in research and teaches Undergraduate and Graduate courses in strength and conditioning, exercise physiology, exercise testing and prescription and research methods.

Dr. Gillis is an environmental physiologist by training and has a research interest in the influence of menthol on human temperature regulation, perception and performance. He is also interested in recovery interventions following exercise-induced muscle damage, and the science of fighting.

Jason has conducted research for the UK Ministry of Defense, charities like the Royal National Lifeboat Institute, rehabilitation hospitals in Canada and Norway, and for the sports drinks and supplement industry.

Dr. Gillis has an international education. He completed his B.Sc (Hon) in Kinesiology at Dalhousie University in Canada, and went on to complete his Masters at KU Leuven University in Belgium, and at the Norwegian School of Sports Science in Norway. Jason completed his Ph.D. in England as part of the Research and Innovation Team at UK Sport in the run up to the Beijing and London Olympic Games.

Whether as a scientist, athlete, or coach, Jason is passionate about sports. He has a background in mixed martial arts and a particular interest in the science of fighting. In his spare time, he provides scientific support to athletes and coaches in combat sports.

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Chapter 1: Fundamentals of Performance Testing in MMA

Introduction

Performance testing is a critical, but all too often overlooked aspect of training in mixed martial arts (MMA). An effective program of testing and monitoring can help fighters and coaches judge the effectiveness of a training plan and evaluate the potential for overtraining or undertraining. Various physical and psychological tests can be used to assess any number of performance factors, or to identify a fighter's strengths and weaknesses, or to classify their skill status and ability level. But it is important to realise that performance tests do have limitations. For example, a test cannot precisely identify a fighter's potential, predict their future performance, or guarantee their success in the cage.

The purpose of this article is to encourage fighters and coaches in MMA to monitor key physical and psychological performance factors in MMA. The MMA Training Bible will teach you to conduct a number of simple sport-specific tests that will form the foundation of a testing program. The results of these tests, when compared over time, can help to identify whether a fighter is responding positively (i.e. supercompensation) or negatively (i.e. undertraining, under-recovery, overtraining) to training.

This chapter will review the fundamentals of performance testing and health screening. Subsequent chapters will teach you, step-by-step, how to conduct simple performance tests in the areas of: psychology skills (identifying strengths and weaknesses, assessing your mood state); body size and composition; muscular power, strength and endurance; anaerobic endurance; aerobic endurance; and sport specific testing.

Effective testing is all about precision and repeatability; you must think like a scientist conducting an experiment. By applying a few fundamental principles of testing, you will greatly increase the accuracy of the tests that you run, and you will improve the overall effectiveness of your monitoring program.

The fundamentals of testing

Any test in MMA should assess a relevant performance factor, like anaerobic or aerobic fitness, muscular strength, power or endurance, or even psychological skills like aggression or focus. These tests should be carried out in a careful and repeatable way so that you can compare the results between different fighters, and/or within the same fighter over time. Testing should be conducted every few months and is best undertaken as a collaborative effort between the fighter, the entire coaching staff (i.e. head coach and trainers) and other relevant support staff.

As a general rule, performance testing is divided into laboratory-based tests and field tests. Laboratory tests are conducted in very controlled environments using precise protocols and expensive equipment that attempts to simulate a real life situation; for example, measuring a fighter's peak oxygen uptake (VO_{2peak}) on a treadmill in a laboratory. In contrast, field tests are measurements run outside of a laboratory; for example, estimating a fighter's peak oxygen uptake by having them run around a 400 m track for a set period of time. The MMA Training Bible assumes that you do not have access to a fully equipped sports science laboratory, and with the exception of measurements of body composition, will show you how to run a series of field tests with minimal equipment.

There are various trade-offs that you should be aware of when you decide to run field test. Generally, data collected from field tests are not as reliable as those data obtained from laboratory tests, but are often more valid due to their similarity with a real life situation. Also, the reliability of a test often suffers in the field because it is difficult to control variables such as wind velocity, temperature, humidity, track conditions, competition and movement patterns. For example, you would likely cover more distance during a 15-minute track run undertaken on a windless temperate day compared to a windy, cold and rainy day. For these reasons, portable data collection systems and field testing equipment are often less reliable than laboratory equipment. This has the effect of introducing unwanted error into your field measurements and it will lower the effectiveness of your monitoring program.

There are a few things that you can do to reduce the error associated with field tests and improve the overall effectiveness of your monitoring program. For example:

- ✓ Before testing, pre-screen fighters for health, medication and nutritional factors that may influence the results of the test. For example, make sure fighters refrain from consuming energy drinks before testing because they can raise heart rate and blood pressure, and influence psychological traits like anxiety. Inadequate hydration or diet (i.e. depleted muscle glycogen) may also influence testing results, so make sure fighters standardize their diets prior to testing (use a food log).

- ✓ Ensure the participant refrains from intense physical activity prior to testing so that they are not fatigued.
- ✓ Ensure participants are tested at the same time of day as their previous test, as things like body temperature and wakefulness change over the day and this can influence the result of your test.
- ✓ The more times you practice a test, especially complex tasks, the better you get. This is called the learning effect, and it can have a dramatic effect on the result of a test. So, before you record the final results of a test, you should have a fighter practice the test enough times to see a plateau in their performance. In this way you can reduce any learning effect by familiarizing the participant with the test before you start.
- ✓ Provide verbal encouragement during the test to ensure the fighter puts in a maximal effort.
- ✓ Ensure testing equipment is working properly. Make a point of knowing everything there is to know about the equipment you are using.
- ✓ Practice your testing technique and standardize it in order to make sure that you are not introducing error into the test (i.e. stopping a watch too soon or too late).

With an understanding of these fundamental concepts, you are ready to start testing. Every testing session that you perform must begin with a health screening of the potential participant. Safety in exercise testing is paramount and it begins with screening the health and exercise history of the *potential* participant and then; if they are fit for testing, gaining their informed consent. This process of pre-screening and gaining consent protects the person that is being tested as well as the person running the tests, and it's the first step in the whole testing process, so don't skip it! You can download a copy of a sample health screening questionnaire and participant consent form on this website. As a side note (and to protect my ass), you should always have your doctor's approval before going ahead with any sort of exercise testing – This is my disclaimer!

With all of this fundamental information out of the way, you are now ready to start going through the tests. Chapter 2 will cover psychological testing. Psychological assessments are very important tools that can be used to quantify your strengths and weaknesses, which can direct future training. Psychological tests can also be used to measure your mood, which can help to identify your potential for over-training.

Chapter summary

If you want to optimise your physical and psychological preparation, and your performance in the cage, you must implement a regular testing and monitoring program that spans all phases of training and stretches across your fighting career.

A test in MMA should assess a relevant performance factor, like anaerobic or aerobic fitness, muscular strength, power or endurance, or even psychological skills.

Tests should be carried out in a careful and repeatable way so that you can compare the results between different fighters, and/or within the same fighter over time.

Testing should be conducted every few months and is best undertaken as a collaborative effort between the fighter and the entire coaching staff.

Field tests are less reliable than lab tests, but you can improve the reliability by doing the following:

- ✓ Before testing, pre-screen fighters for health, medication and nutritional factors.
- ✓ Ensure the participant refrains from intense physical activity prior to testing
- ✓ Test fighters at the same time of day
- ✓ Reduce any learning effect by familiarising participants with the test
- ✓ Provide verbal encouragement during the test
- ✓ Make sure testing equipment works properly
- ✓ Practice your testing technique

Chapter 2: Psychological Profiling and Mood States

Introduction

Regularly monitoring the physical and psychological factors that influence your performance in the cage is one of the most basic, but most often overlooked, aspects of training in mixed martial arts (MMA). An effective testing and monitoring program can help fighters optimise their physical and psychological preparation, and their performance on fight day. A good monitoring program can accomplish a lot. It can help coaches profile the skills, strengths and weaknesses of their fighters; it can help you monitor physiological and psychological adaptations to training, which can help you avoid undertraining and overtraining; and the results of performance tests can be used to identify training objectives and guide future training.

This article is all about giving fighters and coaches the tools and information that they need to regularly and effectively monitor physical and psychological performance factors throughout the year. In Chapter 1, we discussed the fundamentals of performance testing. Although we didn't cover any actual tests, it's probably the most important article, because it lays out the guiding principles that will improve the reliability of each test you run.

Chapter 2 will teach you how to use a few tools from sport psychology. The first set of assessments are 'psychological profiles', the second assessment is a mood state questionnaire. Psychological profiling is a very important tool that fighters and coaches can use to quantify strengths and weaknesses in areas such as physical conditioning, technical development, and psychological skills. Building your awareness in each of these areas can help you identify training objectives and guide your training plan all year round.

The MMA Training Bible also suggests that fighters regularly monitor their mood, as it can be a sensitive measure of overtraining. For example, feeling apathetic (having no interest, no feeling or no concern) or having a depressed mood, decreased self-esteem, feeling emotional instable, restless, or irritable are all associated with overtraining. The Brunel mood scale questionnaire (BRUMS) is a psychological tool that can help you measure your mood, and help to identify your potential for overtraining. When used together, both the performance profiles and the BRUMS can dramatically improve the effectiveness of your testing and monitoring program. In the remainder of this chapter we shall explain how you can start using these psychological tools immediately.

Performance profiles

Performance profiles can help you reflect on and become more aware of the performance qualities necessary for successful MMA performance; they can also help you identify your strengths and weaknesses in the areas of technical development, physical conditioning and psychological skills. The performance profiles used by the MMA Training Bible were derived from the work of Butler & Hardy (1992), but we adapted them to better suit fighters and coaches in MMA.

To get stated, the first thing you need to do is download and print off your own copy of the performance profiles in the accompanying data collection booklet. Note I've also displayed the performance profiles in Figure 1 (below). Using each of the profiles, rate your current perception of your ability in each quality using a scale of 1 (lowest possible ability) to 10 (Professional ability) by shading in the pie sections to the appropriate level. It is advisable that both the coach and the fighter complete their OWN profile, then compare the results as a team, and identify the most important areas of improvement. These areas of improvement often become your training objectives, and should provide focus to your overall training plan. As a general rule, fighters and coaches should aim to fill out these profiles every month or so, or as needed.

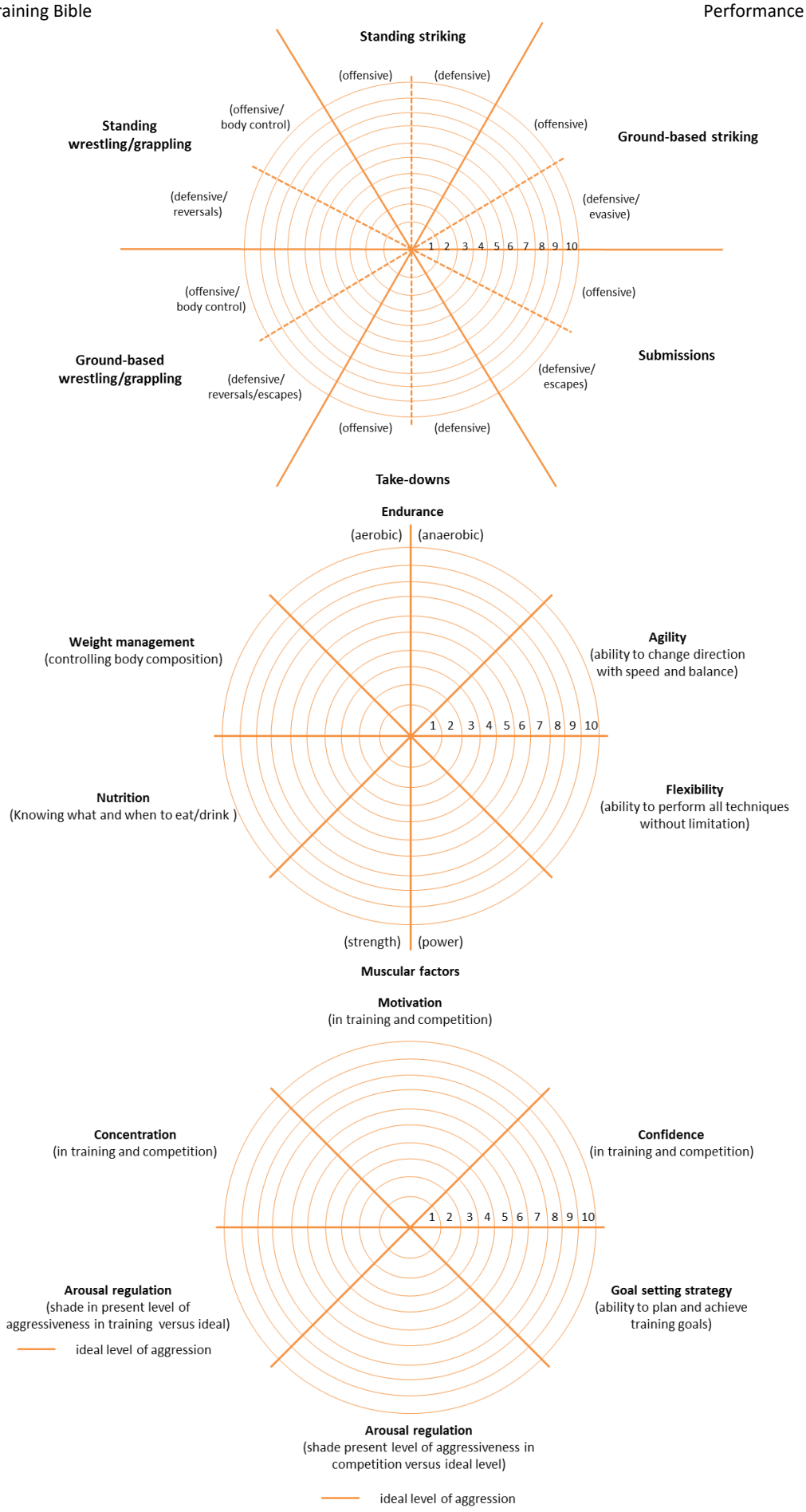


Fig 1. Performance profile for technical development, physical conditioning and psychological skills.

Measuring Mood States: The Brunel Mood Scale

Psychological tools that measure your mood can help to identify your potential for overtraining. The Brunel mood scale questionnaire (BRUMS) serves to describe current mood states using 24 mood descriptors, such as angry, confusion, depression, fatigue, tension, happiness and vigour. You assign a score to each descriptor using a 5-point scale (0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, 4 = extremely). The questionnaire takes a few minutes to complete and can be used to monitor overtraining.

First, download and print off your version of the BRUMS in the accompanying data collection booklet. Note I've also displayed the performance profiles in Figure 2 (below). Remember, the BRUMS is a list of words that describe feelings people have. Please read each one carefully and then circle the answer that best describes HOW YOU FEEL RIGHT NOW. Make sure you respond to every word. After you're done, add the responses to each of the 32 questions according to the subscales on the right hand side of the page and arrive at a final score for each subscale. The total score for each subscale is what you're after. As the months go by, you can monitor how your mood changes and this can give you some indication as to whether you are overtraining.

	Not at all	A little	Moderately	Quite a bit	Extremely	SCORING FOR THE BRUMS-32 (Add the responses for the responses to each of the subscales)		
1. Active	0	1	2	3	4	Subscale	Scores	Total
2. Alert	0	1	2	3	4			
3. Angry	0	1	2	3	4	Anger	ANGRY (3) ___+ ANNOYED (4)___ + BAD TEMPERED (6) ___ + BITTER (7) ___	
4. Annoyed	0	1	2	3	4			
5. Anxious	0	1	2	3	4			
6. Bad tempered	0	1	2	3	4			
7. Bitter	0	1	2	3	4	Tension	ANXIOUS (5)___+ NERVOUS (20)___ + PANICKY (21)___ + WORRIED (30) ___	
8. Calm	0	1	2	3	4			
9. Cheerful	0	1	2	3	4			
10. Composed	0	1	2	3	4			
11. Confused	0	1	2	3	4	Depression	DEPRESSION (13) ___ + DOWNHEARTED (14) ___ + MISERABLE (19) ___ + UNHAPPY (28) ___	
12. Contented	0	1	2	3	4			
13. Depressed	0	1	2	3	4			
14. Downhearted	0	1	2	3	4			
15. Energetic	0	1	2	3	4	Vigour	ACTIVE (1) ___+ ALERT (2) ___ + ENERGETIC (15) ___ + LIVELY (18) ___	
16. Exhausted	0	1	2	3	4			
17. Happy	0	1	2	3	4			
18. Lively	0	1	2	3	4			
19. Miserable	0	1	2	3	4	Fatigue	EXHAUSTED (16)___ + SLEEPY (25) ___ + TIRED (26) ___ + WORN-OUT (29) ___	
20. Nervous	0	1	2	3	4			
21. Panicky	0	1	2	3	4			
22. Relaxed	0	1	2	3	4			
23. Restful	0	1	2	3	4	Confusion	CONFUSED (11)___ + UNCERTAIN (27)___ + MIXED-UP (31)___ + MUDDLED (32) ___	
24. Satisfied	0	1	2	3	4			
25. Sleepy	0	1	2	3	4			
26. Tired	0	1	2	3	4			
27. Uncertain	0	1	2	3	4	Happy	CHEERFUL (9)___ + CONTENT (12)___ + HAPPY (17) ___+ SATISFIED (24)___	
28. Unhappy	0	1	2	3	4			
29. Worn-out	0	1	2	3	4			
30. Worried	0	1	2	3	4			
31. Mixed-up	0	1	2	3	4	Calmness	CALM (8) ___+ COMPOSED (10)___ + RELAXED (22)___ + RESTFUL (23)___	
32. Muddled	0	1	2	3	4			

Fig 2. The Brunel Mood Scale Questionnaire.

Chapter summary

- ✓ Regularly monitoring the physical and psychological factors that influence your performance in the cage is one of the most basic, but most often overlooked, aspects of training in MMA.
- ✓ Performance profiles can help you reflect on and become more aware of the performance qualities necessary for successful MMA performance; they can also help you identify your strengths and weaknesses in the areas of technical development, physical conditioning and psychological skills. Using each of the profiles, rate your current perception of your ability in each quality using a scale of 1 (lowest possible ability) to 10 (Professional ability) by shading in the pie sections to the appropriate level.
- ✓ The Brunel mood scale questionnaire (BRUMS) serves to describe current mood states using 24 mood descriptors, such as angry, confusion, depression, fatigue, tension, happiness and vigour. You assign a score to each descriptor using a 5-point scale (0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, 4 = extremely). The questionnaire takes a few minutes to complete and can be used to monitor overtraining.
- ✓ Keep your results in a safe place and compare your results over time.

Chapter 3: Flexibility

Introduction

Range of motion (ROM) is the degree of motion that occurs at a joint. It is influenced by connective tissue structure, activity level, age and gender, and it is very specific to the joint (i.e. ball/socket joints vs hinge joint).

The optimal level of flexibility changes with the sport i.e. gymnasts need more shoulder flexibility than cyclists. It is important to note that injury risk increases when an athlete leaves the optimal range of flexibility for their sport. Both hyper-flexibility and hypo-flexibility increase injury and imbalance in flexibility may also increase injury risk.

Flexibility is a measure of ROM with two components. Dynamic flexibility is the available range of movement during active movements and it requires voluntary muscle actions. Static flexibility is the range of possible movement about a joint during passive movement. In this chapter you will assess dynamic flexibility with a sit-and-reach test.

Sit-and-reach test

The sit-and-reach is probably the most widely used flexibility test. It provides an assessment of the flexibility of the hamstrings, hip and lower back, which are important for many activities.

Testing procedures for the sit-and-reach

1. Clients should perform a short warm-up prior to this test and include some stretches (i.e. modified hurdlers stretch). The participant should refrain from fast, jerky movements, which may increase the possibility of injury. The participant's shoes should be removed.
2. Place a measuring tape on the floor with a right angle line (made with tape) at the 15-inch mark. The client sits with the measuring tape between the legs, with legs extended at right angles to the taped line on the floor. Heels of the feet should touch the edge of the taped line and be about 10 to 12 inches apart.
3. The client should slowly reach forward with both hands as far as possible, holding this position for approximately 2 s. Be sure that the participant keeps the hands parallel and does not lead with one hand. Fingertips can be overlapped and should be in contact with the measuring tape.
4. The score is the most distant point (cm or inches) reached with the fingertips. The best of two trials should be recorded. To assist with the best attempt, the client should exhale and drop the head between the arms when reaching. Testers should ensure that the knees of the participant stay extended; however, the participant's knees should not be pressed down. The client should breathe normally during the test and should not hold his/her breath at any time.

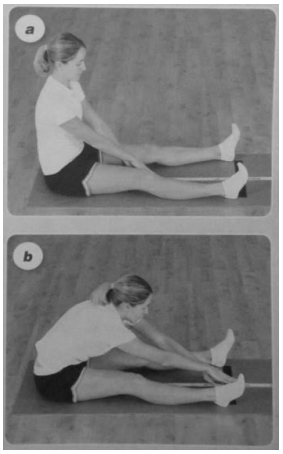


Fig 3. example of Sit-and-Reach using tape measure

Chapter Summary

In this chapter you learned how to simply assess flexibility. You can access the data collection booklet and instructions for this test in the accompanying download.

Chapter 4: Body Size and Composition

Introduction

If you want to optimise your preparation and your performance in the cage on fight day, you should consider implementing a regular testing and monitoring program. The purpose of this article is to show you how to effectively monitor the physical and psychological performance factors most relevant to MMA.

Chapter 3 will focus on measures of body size and body composition. Body size refers to things like your weight, height, body mass index (BMI) and the circumference of various limbs (i.e. chest, arms). Body composition refers to the distribution of fat and lean muscle tissue around your body. Because MMA is a weight class sport, it is essential that fighters and coaches are familiar of the most common methods to assess body size and composition.

This article is meant to provide you with a simple overview of measures of body size and composition. Because a high level of skill and precision is required to accurately measure both, The MMA Training Bible recommends that you find a suitably trained individual to perform them for you. If you are interested in learning more about this field of science or perhaps gaining certification, refer to the official website of The International Society for Advanced Kinanthropometry (ISAK; isakonline.com). The remainder of this article will provide a simple overview of common measures of body size and composition.

Body size

Body size is an important factor that can determine performance in MMA. Typical measurements include body mass, the circumference of limbs, bone breadths and limb lengths. Circumference measures of the chest, waist, arms and legs are particularly useful in tracking muscular development across your fight plan.

In order to measure body mass, you'll need access to weighing scales. When performing these measures, try to use the same scales every time and make sure they are calibrated appropriately. You should also allow for the weight of clothing by either removing it before hand, or weighing it separately and subtracting it from the total weight. As one litre of water weighs 1 kg, you'll need to make sure that participants are not over or under hydrated when the measure is taken. To measure height (cm or m), use either a standiometer like that shown in the picture below, or a simple measuring tape.

Fig. 4. Tools for measuring body size

Another frequently used measure of body size is the body mass index (BMI), which can be easily calculated by dividing your body mass (kg) by your height (m^2) (BMI = kg/m^2). For example, a 70 kg individual with a height of 1.7 m (which equals 2.89 m^2 [i.e. 1.7 m x 1.7 m = 2.89 m^2]) would have a BMI of 24.2, which is considered 'normal'. Keep in mind that BMI does not consider body composition, so it may not be the most appropriate measure for the athlete population.

Body circumference can be a useful measure to track both muscular hypertrophy (muscles getting bigger) and fat loss across during training. In order to measure limb circumference, you'll need measuring tape. Try to use a narrow (< 7 mm wide), but flexible and tough tape that doesn't stretch. It should probably be at least 1.5 m long and it should read centimetres (cm) and millimetres (mm). Typical anthropometric tape typically looks like this:

Fig. 5. Flexible measuring tape for circumferences.

Below in Figure 6 are examples of circumferences that are commonly measured, along with a brief description of how the measure is taken. For more information, refer to official manuals from The International Society for Advanced Kinanthropometry (i.e. ISAK, 2001).

Chest

Participant stand with arms raised to sides. Measure at the mid-level of the sternum after the participant lowers their arms by their side and at the end of an exhale.

Arm Girth (Relaxed)

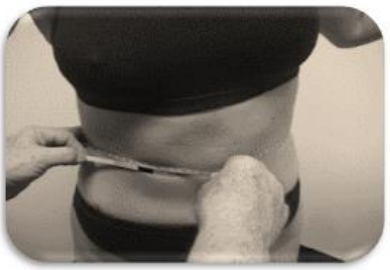
Participant stands relaxed with arms hanging at sides. Measure right arm at a marked spot that is half way up the upper arm.

Arm Girth (Flexed)

Participant stands with right arm raised such that it is horizontal with the ground and the palm is facing inwards. Ask the participant to flex and measure at the peak of the bicep.

(ISAK, 2001)

Waist Girth



Participant stands with arm folded. Take measurement at the narrowest point between the lowest rib and the hip bone, after the participant relaxed and lowers their hands by their sides, and at the end of an exhale.

Gluteal Girth

Participant stands with arm folded and feet together. Take the measurement at the largest point, which may correspond to the level of the pubic bone.

Calf Girth

Participant stands with arms relaxed hanging by sides. Take the measurement at the biggest part of the calf

(ISAK, 2001)

Fig 6: Sample circumference measurements

Body composition

Body composition refers to the absolute amount of fat and non-fat tissue within the body. Fat mass is the total mass of all fat within the body and fat-free mass is the total mass of all tissues within the body, excluding fat. The percentage of body fat is the ratio of fat mass to fat-free mass.

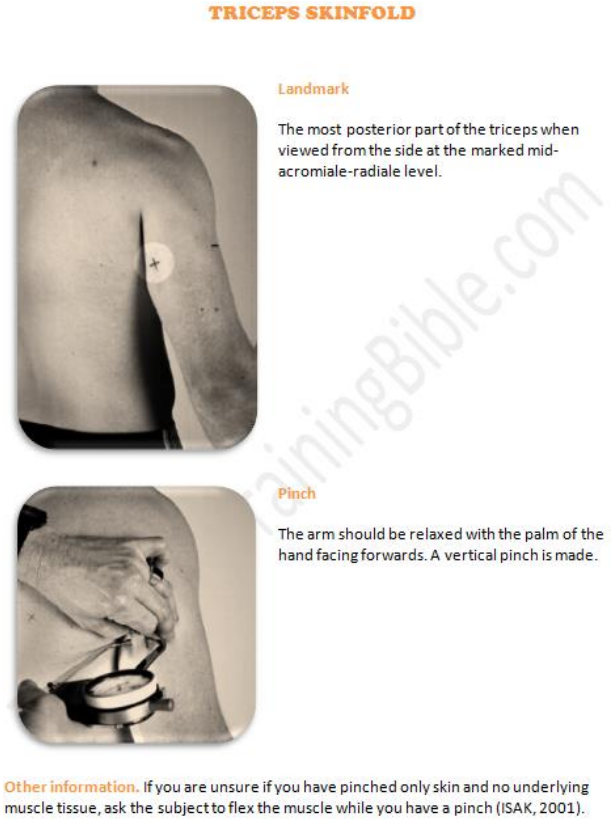
Most fighters in MMA, like other weight-class sports, should aim to lower their fat mass, as this will improve their efficiency of movement; but there is little data reviewing typical body fat values in MMA. As a reference, elite male judokas typically have body fat in the range of 7 % to 14 %, females range from 15 % to 22 % (Franchini et al., 2011). Wrestlers tend to have a mean body fat percentage of around 3 % to 13 % during the in-season, and 8 % to 16 % in the off-season (Callan et al., 2000; Horswill, 1992). The percentage of body fat tends to rise with weight class in wrestling, with heavy wrestlers showing body fat percentages from 15 % to 26 % (MIrzaei et al., 2009).

There are many ways to have your body composition assessed and some are more complicated and expensive than others. For example, pinching the skin with skinfold callipers is a very common method that can be quite reliable if done by an experienced practitioner, although the best way to measure body fat is by using an expensive underwater hydrostatic weighing system. The MMA Training Bible advises you to have your body composition evaluated before and throughout your fight plan by a suitably trained practitioner.

Skin fold calipers are used to pinch folds of your skin. Calipers come in many formats, some more expensive than others; however, they require regular and careful calibration in order to ensure the accuracy of measurement. Here is an example of what they look like.

Fig. 7. Skinfold calipers

Below are examples of some of the more common skin fold measures that are taken, along with a brief description of how to precisely take the measure. For more information, refer to official manuals from The International Society for Advanced Kinanthropometry (ISAK, 2001).



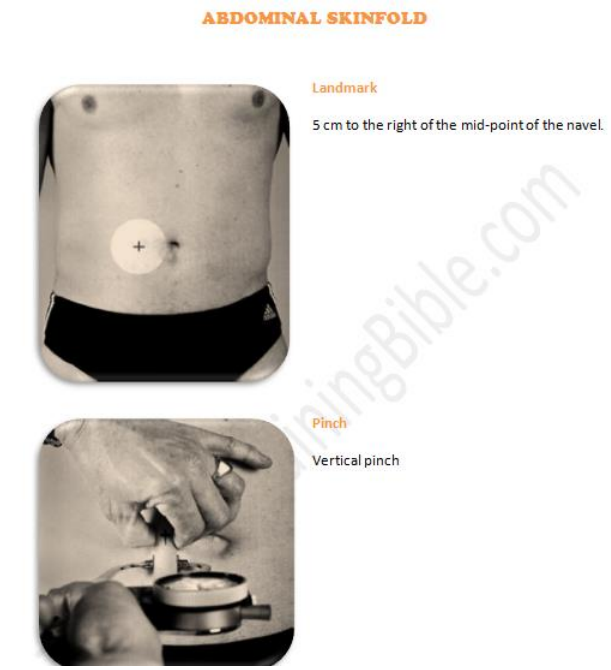


Fig. 8. Abdominal skinfold site

ILIAC CREST SKINFOLD

Landmark

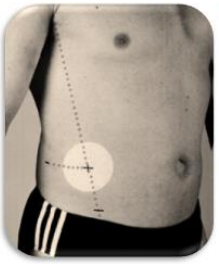
Immediately above the iliac crest (top of hip bone), on the most lateral aspect (side).

Pinch

The fold is directed anteriorly and downward in line with the natural fold of the skin. The right arm should be held across the body to keep it away from the measurement area.

Other information see (ISAK, 2001).

SUPRASPINALE SKINFOLD



Landmark

The site is at the intersection of the two lines

Step 1: Landmark iliospinale. The underside of the front of the hip bone

Step 2: Draw line straight form the top of the hip

Step 3: Draw line from armpit to Step1 line. Take measure at intersection of lines.

Pinch

The fold is directed anteriorly and downward in line with the natural fold of the skin. The right arm should be held across the body to keep it away from the measurement area.

Other information see ISAK (2001).

SUBSCAPULAR SKINFOLD

Landmark

The site is 2 cm along a line running laterally and obliquely downward from the Subscapulare landmark (which is the undermost tip of the inferior angle of the scapula) at a 45° angle.

Pinch

The pinch is made following the natural fold of the skin. On a line running laterally (away from the body) and downwards (at about 45 degrees).

Other information. see ISAK (2001)

FRONT THIGH SKINFOLD

Landmark

At the mid-point of the distance between the inguinal fold and the anterior surface of the patella on the mid-line of the thigh

Pinch

Vertical pinch.

Other information: If the fold is difficult to raise, ask the participant to lift the underside of the thigh with both hands (ISAK 2001).

BICEPS SKINFOLD

Landmark

At the most anterior part, mid-acromiale-radale level.

Pinch

The arm should be relaxed with the palm of the hand facing forwards, shoulder externally rotated. A vertical pinch, parallel to the long axis of the arm, is made at the landmark.

Other information. If you are unsure if you have pinched only skin and no underlying muscle tissue, ask the subject to flex the muscle while you have a pinch (ISAK, 2001).

MEDIAL CALF SKINFOLD

Landmark

The most medial aspect of the calf at the level of the maximal girth.

Pinch

Vertical pinch when knee is bent at 90° and the foot rests on a box.

Other information. If the fold is difficult to raise, ask the participant to lift the underside of the thigh with both hands (ISAK 2001).

Fig. 9. Assorted skinfold sites

Data collection table

Below you will find an example of a typical data collection sheet that can be used in conjunction with all of the previously described measures. Feel free to download your own copy of the accompanying data collection sheets, along with all of the measures previously described.

Date of Birth

Measure no.	1	2	3	Average
Body mass (kg)				
Stretch stature (cm)				
BMI	-	-	-	
Triceps skin fold				
Subscapular skin fold				
Biceps skin fold				
Iliac Crest skin fold				
Supraspinale skin fold				
Abdominal skin fold				
Front Thigh skin fold				
Medial Calf skin fold				
SUM OF 8 SKINFOLDS				
Chest girth (cm)				
Arm girth relaxed (cm)				
Arm girth flexed and tensed (cm)				
Waist girth (cm)				
Gluteal girth (cm)				
Calf girth (cm)				

Fig. 10. Sample data collection table

You might notice that the percentage of body fat is not listed in the table below. Although most people like to talk about the % body fat, many scientists feel that it is not as accurate a measure of body composition as the skin fold measure. This is because a rather complicated formula is required to calculate % body fat. If you want to see for yourself, check out the research by Durnin & Womersley (1977). If you're looking for a useful summary measure of total body fat, then consider adding together all of the skinfold measures into one number, you can call it 'the sum of 8 skin folds', as we have in the table.

Chapter Summary

This chapter provided you with a simple overview of measures of body size and composition. Body size refers to things like your weight, height, body mass index (BMI) and the circumference of various limbs (i.e. chest, arms). Body composition refers to the distribution of fat and lean muscle tissue around your body. Because MMA is a weight class sport, it is essential that fighters and coaches are familiar of the most common methods to assess body size and composition. Because a high level of skill and precision is required to accurately measure both, The MMA Training Bible recommends that you find a suitably trained individual to perform them for you.

Chapter 5: Muscular Power

Introduction

Performance testing is not just for sport scientists and elite athletes; it's a lot simpler than you think and there are lots of reasons why you should be doing it. Using the tests described in this article you will be able to: better judge the effectiveness of your training plan; optimise your overall physical and mental preparation for fight day; assess how your body is responding to training and help evaluate the potential for overtraining or undertraining; identify strengths and weaknesses and create training objective; and classify your skill status and ability level.

The present article will show you how to assess muscular power. MMA is a sport made up of explosive offensive and defensive techniques, many of which require a high degree of muscular power. From a scientific perspective, muscular power refers to the speed or rate of a muscular contraction and it is equal to the force that your muscles apply over a given distance, divided by the time it takes to perform the technique. Here is the equation:

Power = (Force x Distance)/Time

Force is very much influenced by strength, and you cannot have a high level of power without being relatively strong. But muscular power is influenced by many factors (Cormie et al., 2011), including; muscle fibre type, composition and cross sectional area, muscle length, pennation angle, and tendon compliance. Other factors like motor unit recruitment, firing frequency, synchronization and inter-muscular coordination are also important. The maximal power that you can generate is also affected by the type of muscle action involved, the time available to develop force, the storage and utilization of elastic energy, interactions of contractile and elastic elements, potentiation of contractile and elastic filaments, and the stretch reflex.

There are many different ways to assess muscular power, but the best way is to use a piece of scientific equipment called an isokinetic dynamometer. If you don't have access to one, we're going to cover two simple tests that you can use. The first test assesses the power of your lower body muscles using a vertical jumping protocol. The second assesses upper body muscular power using a seated medicine ball toss. Both tests are covered below.

Vertical jump test

Equipment: For this test you will need a measuring tape, chalk or a marker, and a scale to measure body mass.

Description: First, the starting reaching height is recorded (shown in figure below). This is just the distance between the floor and the fingertip of an outstretched arm measured when the participant is standing next to a wall. The ending fingertip position will be identified on the wall by the chalk dust/tape (or other mark) left by the participant's fingertip at the top of their jump (show in figure). Your vertical jump height is simply calculated by finding the difference between the maximum jump height (cm) the standing reach (cm).

Without a preparatory step or a counter-movement, the participant will stand with their feet shoulder width apart and perform a vertical jump by squatting down until the knees are bent to 90°, holding for a count of 3 seconds, and jumping as quickly and as powerfully as possible, with the goal of jumping as high as possible.

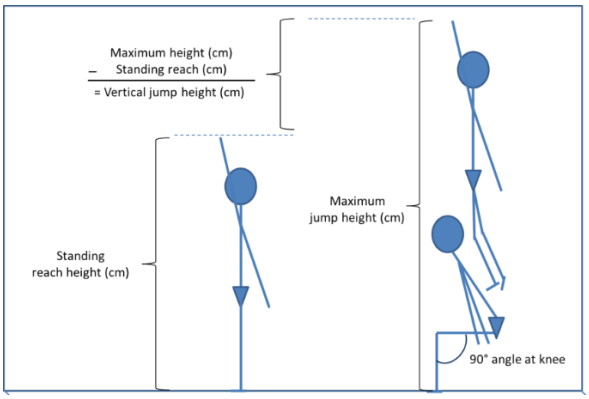


Fig. 11. Vertical Jump testing protocol

During the jump, the dominant arm should reach upward in an attempt to touch the highest point possible. A total of 3 attempts should be made, each separated by 30 s of rest.

Although recording the height of the jump is a pretty good measure of lower body power, you can also calculate the peak power of the vertical jump using a formula developed by Sayers *et al.,* (1999);

Peak power (watts) = [60.7 x VJ height (cm)] + [45.3 x body mass (kg)] – 2055

Example calculation

Peak power (watts) = [60.7 x 50 cm] + [45.3 x 75 kg] – 2055
Peak power (watts) = [3035] + [3397.5] – 2055
Peak power (watts) = [6432.6] – 2055
Peak power (watts) = ***4377.5 W***

Seated medicine ball throw

Equipment: Medicine ball with a set weight (i.e. 5kg)

Description: The participant should sit down on the floor against a wall. They should be sat on and centred over a tape measure that touches the wall behind them. The tape measure should be centred between the feet, buttocks, and the upper part of the back and head. Participants should sit with their feet (at least heels) pressed on in floor.

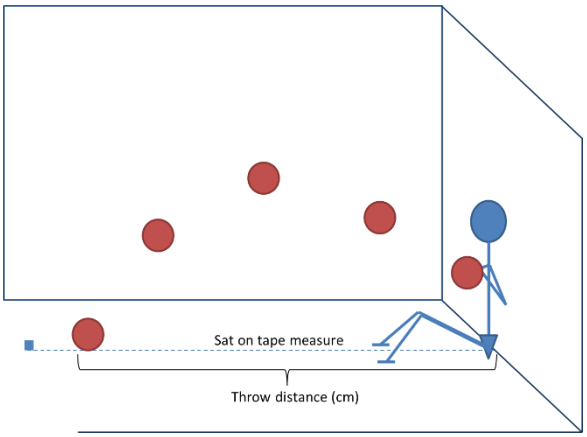


Fig 12. Seated medicine ball toss testing protocol

Participants are to hold the medicine ball with both hands in front of the chest, fingers behind the ball, and elbows slightly raised (45°), then throw the ball forward as far as possible. During the initiation of the throw the head and back should not lose contact with the wall, and no rocking before the throw is allowed. Perform two attempts separated by 30s rest and document the throw distance up to 1 cm.

Chapter Summary

This Chapter provided you with a simple overview of measures muscular power. The first test assesses the power of your lower body muscles using a vertical jumping protocol. The second assesses upper body muscular power using a seated medicine ball toss. You can access the data collection booklet and instructions for both tests in the accompanying download.

Chapter 6: Muscular Strength

Introduction
A good understanding of exercise science can help fighters and coaches in mixed martial arts (MMA) effectively use tests to optimize physical and psychological performance. With the right performance monitoring program, fighters and coaches can: better judge the effectiveness of a training plan; assess the body's response to training; help evaluate the potential for overtraining or undertraining; identify strengths and weaknesses; create training objective, and classify skill status and ability level.

MMA involves a lot of wrestling and grappling, which requires a high degree of muscular strength. Strength is simply the maximal force a muscle can generate, and unlike muscular power, time is not a factor. In scientific terms, muscular strength is the maximal force (measured in Newtons [N] or torque [N·m]) that a muscle or muscle group can generate at a specified velocity (Baechle & Earle, 2008).

Your strength is mainly influenced by the number of motor units activated and their firing rates. A motor unit is made up of a single nerve and a few hundred muscle fibers, all of which contract when the nerve fires. But strength is also influenced by a lot of other factors (Baechle & Earle, 2008), like the level of motor unit synchronization. For example, if all muscles are activated at the same time, the rate of force development should increase. The stretch-shortening cycle can also influence strength; when you rapidly stretch a muscle it stores energy that can increase the rate of force development when the muscle contracts, like a rubber band. The degree of neuromuscular inhibition is another factor that influences strength; when the joint is heavily loaded, it tends to stiffen up to protect it from injury. With training, you can reduce this extra muscle activation. The muscle fibre type also influences strength; slow twitch fibres are characterised by lower levels of force production compared to fast twitch fibres. Lastly, the degree of muscle hypertrophy influences strength; simply put, the bigger the muscle, the greater its force generating capacity.

There are lots of different ways to measure muscular strength. One of the best ways is to use an expensive piece of equipment called a dynamometer; but this isn't very practical, so we're going to show you how to assess muscular strength using a few common pieces of gym equipment. The first test of strength we'll discuss is the bench press test; the second test is the squat. Note that before you attempt these tests you should have a solid base of strength training with good technique in both lifts, and at least two suitably trained spotters.

5 and 3 repetition maximum (RM) bench press
Equipment: typical bench press set up, 2 spotters and safety clamps, data collection sheet.

Description: Have the participant take a 15-minute self-organised general warm-up and then familiarize them with the bench press technique. The participant will then perform a specific warm-up with a light resistance that they can easily complete for 5 to 10 repetitions. Following this they are to take about 1-minute rest. Next, estimate a load that will allow the participant to complete 3 to 5 repetitions (which ever test is chosen).

Participants are always expected to hold a solid technique during the testing process – TECNHIQUE AND SAFETY BEFORE PERFORMANCE!!

When the weight is set on the bar and the participant lies on the bench, the spotter will spot the applicant from behind. A second tester will position him/herself close to the bench. The participant is expected to perform as many repetitions with the set weight as possible: The bar should move smoothly and touch the chest at its lowest point. The bar should move over the chest, not pressed out of the shoulder. The arms should be completely extended on the highest point but not overstretch and breathing should be continuous. The whole back should always have contact with the bench during the motion.

The spotter is to help the participant put the weight back on the cradle and supports the participant if the movement gets stuck. If the spotter is required to intervene, the respective repetition does not count and no further reps are to be attempted at this point in time.

Record the number of repititions with each given weight; even if a 5 RM attempt ended up being 6 or 4 reps. Evaluate the form/technique of the press against the criteria mentione above on a scale from 1 - 3 (1 = beginner, 3 = excellent).

5 and 3 RM Squat
Equipment: Standard squat rack set up; 3 spotters, safety clamps, data collection sheet.

Description: Have the participant take a 15-minute self-organised general warm-up and then familiarize them with the Squatting technique. The participant will then perform a specific warm-up with a light

resistance that they can easily complete for 5 to 10 repetitions. Following this they are to take about 1-minute rest. Next, estimate a load that will allow the participant to complete 3 to 5 repetitions (which ever test is chosen).

Participants are always expected to hold a solid technique during the testing process – TECNHIQUE AND SAFETY BEFORE PERFORMANCE!!

When the weight is set on the bar and the applicant is standing under the bar, the tester will spot the applicant from behind. The two other testers will position themselves to the left and right of the bar.

The participant is expected to perform as many repetitions with the set weight as possible. The bar should move smoothly through the entire movement. If not agreed otherwise with the participant, a full squat should be performed, i.e. with hips parallel to the knees. If only a half squat is performed (90° knee angle), this is to be noted on the evaluation sheet. The back of the applicant should always be straight or in a slight hollow back position. Breathing should be continuous. The spotter is to help the participant in putting the weight back on the cradle. The spotter will support the applicant if the movement get stuck. If the spotter is required to intervene, the respective repetition does not count and no further reps are to be attempted at this point in time.

Document the number of repititions with each given weight, even if a 5 RM attempt ended up being 6 or 4 reps.Evaluate the form/technique of the squat against the criteria mentione above on a scale from 1 - 3 (1 = beginner, 3 = excellent).

Chapter Summary

This article provided you with a simple overview of measures muscular strength. One test assesses the strength of your lower body muscles using a squatting protocol. The second assesses upper body muscular strength using a bench press test. You can access the data collection booklet and instructions for both tests in the accompanying download.

Chapter 7: Muscular Endurance

Introduction

An effective program of testing and monitoring can help fighters and coaches in MMA accomplish a lot. It can help them judge the effectiveness of a training plan and evaluate the potential for overtraining or undertraining. Various physical and psychological tests can be used to assess any number of performance factors, or to identify a fighter's strengths and weaknesses, or to classify their skill status and ability level.

MMA involves a lot of sustained movements, like prolonged combination or submission attempts and defences that are largely influenced by the endurance capacity of your muscles. Muscular endurance is defined as the ability of a muscle or muscle group to repeatedly exert sub-maximal force against a resistance for a certain period of time (Plowman & Smith, 2011). It is primarily influenced by the capacity of the anaerobic glycolytic system, which supports maximal activity in the 30 s to 90 s range. For this reason, muscular endurance is primarily limited by the build-up of hydrogen ions and inorganic phosphate, which interfere with enzymatic reactions and impair muscle contraction (Plowman & Smith, 2011; Westerbalad et al., 2002).

Tests of muscular endurance can be static or dynamic, use an absolute load or a percentage of a maximum voluntary contraction or 1 repetition maximum (1RM), and typically last 30 s to 90 s. Muscle endurance is specific to the muscle group tested, speed of the contraction, type of contraction (i.e. static or dynamic) and the joint angle assessed.

Muscle endurance can be assessed directly using electromyography (EMG), which measures the fall in muscle action potentials over prolonged or repeated contractions. Force transducers and strain gauges; when built into force plates or dynamometers, can indirectly assess muscle endurance by measuring the fall in force production over prolonged or repeated contractions. Many valid and reliable protocols exist for assessing muscular endurance using either of the above methods, but they require expensive equipment and are inaccessible to most athletes and coaches. For these reasons, it is desirable to have a range of inexpensive tests that can be administered with minimal equipment and technical training.

Callisthenic exercises are simple movements that require little equipment and technical expertise. These movements have long been utilized by athletes and coaches to assess muscular endurance in a field-based setting. Because callisthenic exercises are body-weight dependent, muscular endurance is assessed by the number of repetitions performed in a given time or until failure, or the according to the duration of time that a static contraction is held. This chapter will teach you how to assess muscular endurance using the partial curl-up test and the push-up test.

Partial curl-up

Equipment: Stop-watch, metronome (not necessary), measuring tape, mat, marking tape

Description: The curl-up test is designed to assess muscular endurance of the abdominal musculature. Performing a partial curl-up with the feet un-sported and the knees flexed appears to maximize abdominal activity and lessen low back strain compared to performing full sit-ups with foot bracing (Nieman, 2011). For this reason, we will use the partial curl-up test. The purpose of this test is to assess endurance of the abdominal musculature; here's how you perform the test:

1. Apply masking tape across a gym mat in two parallel lines, 10 cm apart.
2. Lay on your back, with the head resting on the mat, arms straight and fully extended at the sides and parallel to the trunk, palms of the hands in contact with the mat, and the middle fingertip of both hands at the 0-mark line. The knees should be bent at 90° angle. The heels must stay in contact with the mat. The test is performed with the shoes on.

Fig. 13. Curl-up testing protocol

3. Set a metronome to a cadence of 50 beats per minute (equivalent to about 1 every 2 seconds). The participant performs as many consecutive curl-ups as possible, without pausing, at a rate of 25 per minute. During each curl-up, the upper spine should be curled up so that the middle fingertips of both hands reach the 10 cm mark. During the curl-up the palms and heels must remain in contact with the mat. Anchoring of the feet is not permitted. On the return, the shoulder blades and head must contact the mat, and the fingertips of both hands must touch the 0 mark.
4. The test is terminated anytime at the participant's discretion, or if they are unable to maintain the proper curl-up technique over two consecutive repetitions.

Push-up test
Equipment: Stop-watch

Description: The purpose of the push-up test is to assess muscle endurance of the triceps, anterior deltoids and pectoralis major. There are separate testing protocols for males and females.

Male protocol: Assume a push-up position with the body rigid and straight, balanced on toes, head up, and hands under the shoulders.

1. A tester places a fist on the floor beneath the participant's chest, who lowers himself until his chest touches the fist, keeping his back perfectly straight; he then raises himself to the starting position.

Fig. 14. Push-up testing protocol

2. The most common performance error is not keeping the back rigid and straight throughout the entire push-up. Rest is allowed in the up position only. The score is the total number of push-ups to exhaustion.

Female protocol: Everything is the same as for the males, except the test is performed from the bent-knee position with feet crossed, knees at 90°, and head up (notice the error in the picture, above). In addition, females should make sure their hands are slightly ahead of her shoulders in the up position, so that her hands are directly under her shoulders on the down position.

1. There are no established criteria for determining how much the torso must be lowered to count as a proper push-up (can you think of any?).
2. Keep the back rigid. The score is the total number of push-ups to exhaustion.

Chapter Summary
This article provided you with a simple overview of measures muscular endurance. One test assesses the endurance of your core muscles using a curl-up test. The second assesses upper body muscular endurance using a push-up test. You can access the data collection booklet and instructions for both tests in the accompanying download.

Chapter 8: Anaerobic and Aerobic Performance

Introduction

If you don't regularly test your performance, how can you be sure that your training plan is effective? A good program of performance testing can help you with this, and a whole lot more. For example, exercise testing can help you optimise your overall physical and mental preparation for a fight; it can help you assess how your body is responding to training and evaluate the potential for overtraining or undertraining; it can help you identify strengths and weaknesses and create training objectives; and it can help to classify your skill status and ability level.

The present Chapter will show you how to assess anaerobic and aerobic performance. MMA is a sport characterised by repeated high intensity, short-duration efforts, interspersed with brief recovery periods. Because this kind of activity is influenced by anaerobic and aerobic energy system you need to perform tests that assess both.

One of the more established tests used to assess your ability to perform repeated high intensity anaerobic efforts like those required in the cage is the running-based anaerobic sprint test. Alternatively, the Balke 15 min track run is a test that can assess your aerobic fitness. Both tests are described in turn below.

Running-based Anaerobic Sprint Test

Equipment: For this test you will need a 35 m track, two stopwatches, two assessors, and counter.

Description: The running-based anaerobic sprint test consists of 6 x 35 m sprints, with 10 s rest between each sprint. The first thing you must do is find a suitable straight-line course and mark off 35 m. After undertaking a suitable warm-up, you're ready to begin the test. Note that one assessor ensures the participant takes only 10 s of rest between each sprint, and another assessor records the time of each 35 m sprint.

To quantify your ability to resist fatigue during the test, use the percentage decrement score (S_{dec}) (Girard et al., 2011), because a good repeated sprint ability is best described by a high average sprint performance. Use the below equation to calculate the $S_{dec.}$

$$S_{dec}\ (\%) = \left(\frac{Sprint1 + S2 + S3 + S4 + S5 + S6}{S_{best}\ x\ 6} - 1\right) x\ 100$$

Below is an example that shows you how to perform these calculations. Note that the fastest sprint time that you achieve during the entire test, and the average sprinting time over all six sprints is also a good performance indicator that you should record.

EXAMPLE A. A GOOD SCORE

	Sprint interval					
	1	2	3	4	5	6
Sprint time (s)	5.0	4.9	5.0	5.2	5.2	5.2

$$S_{dec}\ (\%) = \left(\frac{5.0 + 4.9 + 5.0 + 5.2 + 5.2 + 5.2}{4.9\ x\ 6} - 1\right) x\ 100$$

$$S_{dec}\ (\%) = \left(\frac{30.5}{29.4} - 1\right) x\ 100$$

$$S_{dec}\ (\%) = (1.04 - 1)\ x\ 100$$

$$S_{dec}\ (\%) = (0.0374)\ x\ 100$$

$$S_{dec}\ (\%) = \underline{3.74\ \%}$$

EXAMPLE B. A POOR SCORE

	Sprint interval					
	1	2	3	4	5	6
Sprint time (s)	5.0	5.1	5.5	5.6	6.0	6.2

$$(\%) = \left(\frac{5.0 + 5.1 + 5.5 + 5.6 + 6.0 + 6.2}{5.0\ x\ 6} - 1\right) x\ 100$$

$$S_{dec}\ (\%) = \left(\frac{33.4}{30} - 1\right) x\ 100$$

$$S_{dec}\ (\%) = (1.113 - 1)\ x\ 100$$

$$S_{dec}\ (\%) = (0.113)\ x\ 100$$

$$S_{dec}\ (\%) = \underline{11.3\ \%}$$

The Balke 15 min track run for aerobic fitness

Equipment: For this test you will need a 400 m track, stopwatch, one assessor, and counter.

Description: The most common test of aerobic fitness is the laboratory-based incremental VO_{2max}

test. The participant performs the test at a predetermined cadence or at a specific work rate that increases at regular intervals, until they can no longer continue. Oxygen and Carbon dioxide, and many other variables are measured with expensive laboratory equipment. It is not possible to perform this test on yourself, but your local university may be able to accommodate you. If you do not have access to a laboratory, try the Balke test described below. The Balke test (Balke, 1963) is a 15-minute test of aerobic endurance. This is somewhat comparable in duration to a typical professional MMA bout (i.e 3 x 5 min rounds). In this test, the participant runs around a 400 m track for 15 minutes, the distance achieved in this time record and used to estimate VO_{2max} using the following formula:

VO_{2max} *= (((Total distance covered (m) / 15) – 133) x 0.172) + 33.3*

Here is an example of how to figure out your VO_{2max} using the formula:

Example A: An Excellent Score
Completed 5000 m in 15 minutes
VO_{2max} = (((5000m / 15) – 133) x 0.172) + 33.3
VO_{2max} = (((333.33) – 133) x 0.172) + 33.3
VO_{2max} = ((200.33) x 0.172) + 33.3
VO_{2max} = (34.45) + 33.3
VO_{2max} = 67.75 ml/kg/min
Example B: An Average Score
Completed 3050 m in 15 minutes
VO_{2max} = (((3050m / 15) – 133) x 0.172) + 33.3
VO_{2max} = (((203.33) – 133) x 0.172) + 33.3
VO_{2max} = ((70.33) x 0.172) + 33.3
VO_{2max} = (12.096) + 33.3
VO_{2max} = 45.396 ml/kg/min

****Female Olympic runners can complete 5000m in around 15 minutes.**

As a reference, most elite male wrestlers and judokas have a VO_{2max} between 50 and 60 $mL \cdot kg \cdot min^{-1}$ (Callan et al., 2000; Franchini et al., 2011; Horswill 1992). But you should remember that although wrestling and judo share some technical similarities with MMA, the matches are much shorter in duration. For example, a typically international wrestling match can last up to 6 minutes (3 periods of 1 or 2 minutes), while judo matches can last up to 10 minutes. A typical MMA match can approach and often exceed 15 minutes (three to five, five minute rounds). This suggests that fighters in MMA require a larger VO_{2max} than their wrestling and judo peers.

Chapter Summary

This article provided you with a simple overview of how to measure anaerobic and aerobic performance, using the running-based anaerobic sprint test and the Balke 15-minute track run; both tests are shown below. You can access the data collection booklet and instructions for both tests in the accompanying download.

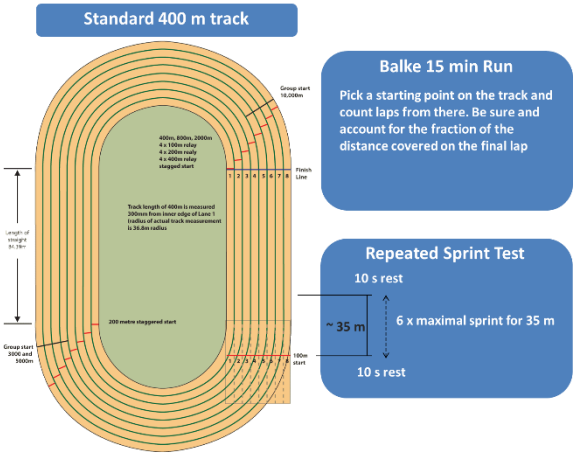


Fig. 15. Track schematics for anaerobic and aerobic tests

Chapter 9: Sport-Specific Testing: The Fighter's Drill

Introduction

The fighters drill attempts to replicate the demands of a typical bout of MMA by having fighters repeat four MMA drills back-to-back, in a self-paced manner, for three, five minute rounds, with one-minute rest between each round. You will require a large area, preferably a cage, one 40 kg grappling dummy, stop watch, a counter, and two experienced pad holders.

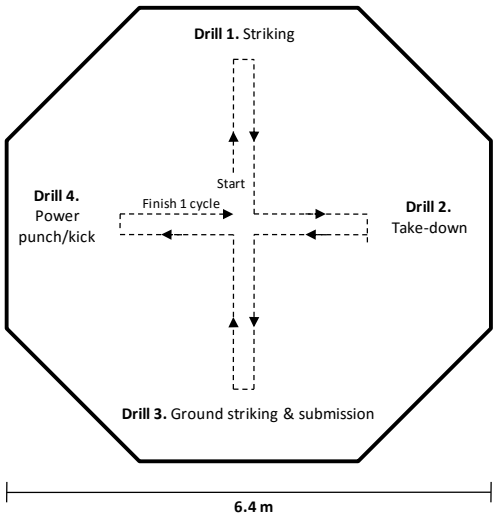


Fig. 16. The fighter's drill.

The fighter will always start in the centre of the cage, facing towards drill 1, in a fighting stance. They will make their way through the four drills back-to-back, in a self-paced manner, for 5 minutes (round 1), then rest for 60 s. Two additional 5 minute rounds will follow the same sequence with 60 s of rest between each round. The test will last 17 minutes (3 x 5 minute rounds, with 2 x 60 s of rest after rounds 1 and 2).

Performance will be assessed by the total number of drills completed during each 5 minute round, and over the entire test. Heart rate (beats/min) can also be recorded throughout the entire test.

The 4 sport specific drills are listed below:

Drill 1. Striking combinations: The fighter will start from the centre of the cage, in a fighting stance, facing an experienced pad holder. At their own pace they will approach the pad holder and perform a jab-cross-hook-cross combination, followed by a jab-cross-switch-kick combination.

Drill 2. Take-down: After drill 1, the fighter immediately returns to the centre of the cage in their fighting stance, facing towards drill 2. At their own pace they will perform a penetration step and pick up a 45 kg grappling dummy that is balanced in a standing position about 1 m from the cage wall. After picking up the dummy, it is carried and pinned against the cage (or wall). Whilst maintaining a body hold, the fighter then performs a suplex that sends the grappling dummy to the ground.

Drill 3. Ground based striking & submission: After drill 2, the fighter immediately returns to the centre of the cage in their fighting stance and faces towards drill 3. At their own pace, they mount the grounded grappling dummy and perform 5 x punching strikes to the head region and an arm-bar submission on right limb. They immediately re-mount the grappling dummy and perform 5 x elbow strikes to the head region, then perform arm-bar submission attempt on the left limb.

Drill 4. Maximal effort striking: After drill 3 the fighter immediately returns to the centre of the cage in their fighting stance, facing towards drill 4. They start the drill at their own pace by performing 3 x rear-hand maximal punches followed by 3 x rear leg maximal kicks.

Below is an example of how the data from the fighter's drill can be collected.

	Round 1	Round 2	Round 3	TOTALS/avg
Number drills completed	20	15	13	48 (20 + 15 + 13)
Heart rate at end of round (beats/min)	175	186	191	184 ([175 +186 + 191]/3)

Chapter Summary

This article provided you with a simple overview of sport-specific testing. You can access the data collection booklet and instructions for this test in the accompanying download.

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