TRAINING FOR COMBAT SPORTS

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

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From the editor

Combat sports often carry with them some sort of taboo, especially with mothers of adventurous boys. I remember as an adolescent being desperate to try my hand at boxing, heavily inspired by the Rocky movies. Even now as a fully grown adult, there's still something inside me that cannot resist the alluring thought of a boxing or wrestling gym. Perhaps the time's now right to see if my mum will let me!

Having edited this mini-report that desire has magnified. There is a phenomenal mixture of mental and physical requirements for combat sports. This report focuses on the physical aspects, which in turn will inevitably lead to a stronger psychological approach.

The opening chapter evaluates what the physical requirements are for combat sports, and how to enhance them, from everything like specific energy systems to making the weight. The middle chapter looks at strength training for wrestling, whilst the final chapter assesses injuries sustained during combat sports. Better keep that away from you know who.

I hope this mini-report helps all you competitors to deliver that knock-out shot.

Sam Bordiss
Editor

Fighting fit! – The scientific approach to combat sport training

Ask your average person what images the phrase 'combat sport training' conjures up and there's a good chance that films such as Rocky or Kickboxer will figure in their response! However the reality is very different, and athletes in this field who want to excel need a much more scientific approach.

Introduction

How many Olympic combat sports can you name? One? Two? Three? In fact, there are five. You probably got judo and boxing, but there's also tae kwon do and two types of wrestling – freestyle and Greco-Roman. Although fencing is a combat sport, it doesn't appear on its own in the Olympics, only as part of the modern pentathlon. Also, while archery and shooting are combat sport derivatives, they're performed against inanimate objects.

We all know that boxers are fit; the intense nature of competing in rounds means that short bursts of explosive energy are required, as well as great endurance, allowing recovery between rounds and bouts. Upper and lower body strength and power are also required, yet the combatants have to make weight limits, which means power to weight ratio becomes important. These demands are required in the other combat sports too.

This article will examine exactly what the fitness requirements are for combat sports, the similarities between them, and also provide some ideas on how to train. While there are obvious differences between the five Olympic combat sports, we will highlight the similarities. For example, research on making the

weight in judo can be applied to freestyle wrestlers, and research on generating endurance in tae kwon do participants can be applied to boxers. In fact, the individual sport differences are traditionally trained during the activity itself and these often depend on the cultural influence of the sport; boxing is British, judo is Japanese, tae kwon do is Korean, Greco-Roman wrestling is… well, you get the idea! As a rule of thumb, the 'traditional' training methods for each combat sport will have been influenced by prevailing ideas in the country of origin of that sport.

What are the fitness requirements for combat sports?

A recent in-depth study on senior and junior British international amateur boxers revealed the requirements of the sport[1]. Current Olympic bouts are of four 2-minute rounds with a 1-minute rest in between. The workload in these rounds is high. Boxers were found to have maximum oxygen uptake (VO_2max) scores of 63.8ml/kg/min, indicating a high aerobic capacity. Heart rate monitors placed on the boxers over four rounds of sparring showed that peak levels were higher than those induced during maximal testing on treadmills. This indicated a large input from the anaerobic system in supplying energy demands, resulting in high post-bout levels of lactate – up to 14mmol/litre.

Upper body strength and power was apparent from the measured punch forces, with some punches generating more than 2,400 newtons. Boxers therefore need to simultaneously work on their aerobic system to aid recovery between rounds, their anaerobic system to help deal with the high workload in each round, and also their upper body power to deliver the right punch – not an easy task!

Tae kwon do athletes fight in two 2-minute rounds with very little upper body work, as 98% of scoring techniques involves kicking[2]. A study on the Czech national tae kwon do team showed that they had less aerobic capacity than boxers with VO_2max scores in the male members of the team of 54.6ml/kg/min[3]. This is not surprising however, considering that tae kwon do rounds are half the duration of those of boxing. The study also showed that after the two rounds, competition bouts

produced lower levels of lactate (11.4mmol/litre) compared to boxing.

By contrast, freestyle wrestlers and judoka fight in a continuous 5-minute bout. They can use legs and arms to provide holds or throws and they require extensive use of isometric contractions, placing large demands on the anaerobic energy systems. One study of Freestyle wrestling in US college athletes found post-competition lactate levels of 19mmol/litre[4]. To gain an idea of how high this is, graded exercise tests to failure on a treadmill tend to produce on in the region of 10mmol/litre of lactate[5]. Another study found that the US national team had VO_2max scores of 54.6ml/kg/min, a significantly lower level than that of boxers, thus highlighting the difference in demands.

Greco-Roman wrestling is now competed over three 2-minute rounds and is a predominantly upper body-based sport, as no attacks below the waist are allowed. Previously, the bout was one of five continuous minutes with a possible 3-minute extension. Existing data on the physiological status of Greco-Roman wrestlers has been collected under the previous (5-minute) bout format; a move to the three 2-minute rounds has almost certainly altered the energy system demands.

In the 1998 World Championships, wrestlers were found to average 14.8mmol/litre of lactate and a work to rest ratio of approximately 3:1 in each bout[6]. A previous study found that amateur wrestlers had VO_2max scores of 52-63ml/kg/min – quite a wide range, but indicating that the fitter wrestlers required extensive use of the aerobic system during their bouts.

An efficient aerobic system has been shown to be essential in reproducing high quality work with limited rest times in activities such as cycling sprinting. While power produced in one sprint is not dependent on aerobic capacity, a recent study showed that the 20 sets of 5-second sprinting with between 10 and 30 seconds rest did require use of the aerobic system[7].

Training the energy systems

Developing fitness for combat sports is not easy. The physical effort required in each bout produces very high levels of lactate,

with high heart rates. Lactate also affects the muscles' ability to work by inhibiting the actin-myosin cross-bridge mechanisms. The body has two mechanisms that 'buffer' this inhibition; bicarbonate (in the cell) and phosphate (between cells), and training can improve both of them. The fitter the fighter, the better able he or she is at tolerating high levels of lactate and recovering more rapidly between rounds (or bouts if there are multiple bouts within the same day of competition).

'Very high levels of lactate in the body can cause vomiting, so care is needed to to progress the volume and intensity of the training gradually'

To reproduce the effort level required to generate the desired training effect outside of competition demands great mental effort, as athletes have to push themselves way beyond what is comfortable. Indeed, very high levels of lactate in the body can cause vomiting, so care is needed to progress the volume and intensity of the training gradually.

Developing a sound aerobic base, or assisting weight control in season can be done by lower intensity steady state work. Working at under 80% of maximum heart rate (MHR) or at a comfortable pace for 20-30 minutes will help develop aerobic fitness, but not overtax the athlete who is fatigued from sparring and strength training[8,9]. For heavier combat athletes, non-running activities such as cycling or the stepmill may be preferable for the longer duration aerobic work, as it places less stress on the lower limbs.

Now for the hard stuff – getting the athletes working at a level that produces lactate in a sufficient quantity to match fight situations. Interval training is very effective here, as is circuit weight training *(see Combat interval training, opposite)*:

Work to rest ratios of 2:1 and 3:1 have been found to be most effective at developing the aerobic and anaerobic systems in grappling sports[10]. Traditional running intervals using these ratios also work, but some exercises that use the upper body should be incorporated because the ability to remove lactate differs between muscle groups and also modes of exercise[11]. When the fighter is either grappling or punching, lactate build up needs to be removed as quickly as possible; if only the legs are efficient at this, then the fighter will fatigue in the upper body sooner.

Combat interval training

All these sessions should be performed at maximum speed and intensity. Warm up for 5 minutes beforehand with gentle running, jogging and arm swings.

1. **Hill runs:** find a steep incline of 20-30m. Run up and down twice, do 10 press-ups, 10 sit-ups, run up and down twice, do 10 **reverse press-ups**, 10 back extensions, do **frog leaps** up the hill and run down twice. Rest for 1 minute and then repeat 2-3 more times.
2. **Psychos:** do 15 burpees, sprint 50m, do 10 clap press-ups followed by a jog back recovery then, 15 close hand press-ups, sprint 50m, 10 tuck jumps and a jog back recovery. Repeat 5-8 times.
3. **Shuttle runs:** mark out 60m and run continuously from one end to the other for 2 minutes with 1 minute's rest; repeat 4-5 times. Look to complete 8-10 shuttles in each set. Alternatively, have a heavy medicine ball or punch-bag at one end and lift from the floor to above the head 10 times every shuttle.
4. **Rope skipping:** do 1 minute of fast rope skipping/30 seonds of press-ups/1 minute of fast rope skipping/30 seconds of sit-ups then take 1 minute's rest. Repeat this set 2-3 more times but add alternative body weight exercises – reverse press-ups, body weight squats, back extensions, squat thrusts, medicine ball lifts etc.

Making the weight

Another thing that all the combat sports have in common is that fighters have to make weight as competitions are all divided into weight categories. The trick is to produce the strongest, fittest fighter within a given weight class. The problem is that there is a direct correlation between strength and the cross-section of muscle size. An increase in muscle size (and therefore mass) results in an increase in strength, which may leave the fighter at a disadvantage if they are the smallest (and weakest) person in the weight category above the one they want to fight in, rather than the strongest in their own weight category.

Most fighters train and live at a higher weight than they fight at, and try to make weight immediately before the competition.

A recent study on US college freestyle wrestlers found that they had an average weight of 75.11kg in-season and three weeks into post-season weighed 80.3kg[10]. This in-season weight loss also resulted in a loss of strength, so the wrestlers were fighting all season under strength.

Usual methods to lose weight in the short term include saunas, skipping, crash dieting and the use of diuretics to provoke fluid loss (and therefore weight). British boxers were found to lose between 6-8.3% of their body weight in the three weeks prior to competing with 5.2% loss occurring in the final seven days and 1.7-2.7% in the final 24 hours[1]. A middleweight boxer may lose as much as 2.5kg in the last day, which is some effort!

Unfortunately, this sudden weight loss has an adverse effect on performance. Going into a fight dehydrated, with lower than normal glycogen levels will lead to a crash at some point, or a severely sub-par performance. Typically the fighter will reduce calorie and fluid intake in the three days prior to the weigh-in and then try and regain the losses before the fight starts. A 54kg wrestler has been reported as eating as little as 334kcal the day before the weigh in, only to bounce back with 4,214kcal the day after[12].

One way to get around this is to reduce excess body fat, which does nothing to enhance performance. Top judoka have higher levels of fat-free mass (FFM) than their less skilful counterparts, allowing them to have more lean tissue and therefore more potential strength than someone who is the same weight but has a higher proportion of fat[13]. Careful monitoring of the diet is necessary, as is some aerobic work, which uses fat as its main fuel source. However, some well-known boxers are almost boastful in their attitude to drinking alcohol and eating meat pies in between bouts, resulting in a massive yo-yo of weight gain and loss every 3-6 months.

Specific fighting strength

How can fighters get stronger without getting bigger and what are the different types of strength work required? In order to promote muscle growth, the muscles have to be placed under load for a longer duration, with relatively little rest time.

Cluster sets

Cluster sets are a method of increasing the total volume of high-quality work that can be performed in a set. The normal method of 'training to failure' certainly produces overload in the target muscles, but at a cost. That is because having completed a set to failure, quite a long time is needed for the muscles to recover in order for that set to be repeated. This downtime in between sets means that the overall intensity of the workout is reduced.

An alternative approach is to use cluster sets, where for example, instead of performing 8 continuous reps, you have a rest between each rep (8 clusters of one rep), or perhaps perform four clusters of two reps with a very short rest in between each cluster. These rests or pauses mean that

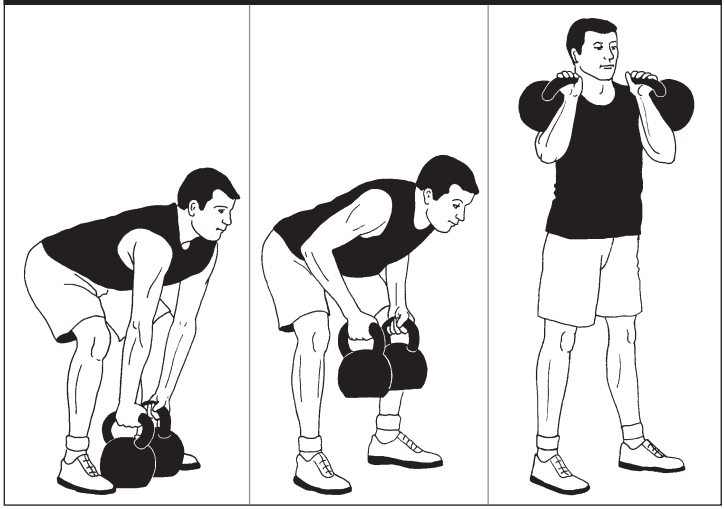
a) you can lift more weight per rep or more reps per set, and
b) reproduce high-quality work throughout the set (and subsequent sets), increasing the overall work performed per unit of time.

Conversely, placing the muscles under heavy loads, but for short durations, will promote strength and moving these loads quickly will produce power. The use of cluster sets *(see box above)* within the workout allows the athlete to lift maximal weight while only being under load for a short duration.

The striking sports (boxing and tae kwon do) require exercises that develop speed and power in the upper and lower bodies respectively. The use of weighted ankle or wrist wraps can be useful in providing added resistance to punching and kicking practice. Too much weight, however, can lead to poor technique; too little will not provide any strength gain. Athletes should therefore follow up any loaded techniques with normal techniques performed at normal speed and power to prevent any skill deterioration.

The grappling sports require speed and power but also a great deal of isometric strength with specific attention being paid to neck strength and grip strength. Exercises such as the barbell clean or the barbell snatch and their dumbbell alternatives require the use of the whole body and help develop power and whole body coordination.

Figure 1: Kettlebell lifts



Squat jumps and medicine ball lifts also help develop power. Using dumbbells, kettlebells and medicine balls also allows multi-planar lifts, which are more relevant to the combat sports than just single-plane lifts *(see figure 1 for example of multi-planar lift using kettlebells)*. Grip strength is developed within strength training sessions just by holding the weights, but it can also be enhanced by introducing some variation. Instead of normal pull-ups, wrap a towel around the bar to increase its size, or hang the towel over the bar and grip each end and pull up. Holding two Olympic disks together instead of using a dumbbell or medicine ball also enhances grip strength.

Neck strength can be developed through exercises such as shrugs, but the use of neck harnesses to perform flexion, extension and rotation exercises will develop specific strength. The neck bridge, which requires the athlete to kneel down and place their head on the floor and then roll forwards, backwards and side to side places load on the neck, and should be done with care. Manual resistance against your own hand or by placing a rolled up towel around the head and pushing with your head while pulling the towel with your hands will develop isometric strength in the neck. Care must be taken on all these exercises,

Combat sport circuit training routine

1. Barbell squats
2. Neck bridge
3. Dumbbell bench press
4. Medicine ball sit-ups
5. Dumbbell bench step-ups
6. Towel pull-ups
7. Disk duck walks (hold a weight disk across the chest, walk across the gym floor with bum level with your knees)
8. Disk figure of 8s (Hold a weight disk at arm's length and make a horizontal figure of 8)

however, to ensure that all directions of movement are trained to prevent muscle imbalances and the corresponding likelihood of injury problems developing.

Circuit training for combat sports

Circuit training is quite a popular method of training amongst combat athletes. The advantage is that a lot of exercises are performed in a short period of time, and that the energy system demands of the sport are matched because the work: rest ratios of the bouts can be applied in the gym. For example, a 2-minute circuit of upper and lower body work of eight exercises performed for 12 seconds each, allowing a 3-second changeover, followed by a 1-minute rest, then repeated three more times, matches the demands of boxing *(see above)*.

The disadvantage of circuit training is that a lot of conditioning is performed in the sport-specific training sessions, such as sparring, or in the case of tae kwon do, repetition of techniques performed in the lesson. Repeatedly working on the same energy system at a high intensity will lead to fatigue and possible over use injuries and could lead to burnout. Instead, if the training demands are high immediately before competition or in season, training for strength should be used. This will allow the fighters to maintain their strength while competing, and limiting the taxing demands on the anaerobic energy systems[10].

Circuit training may be better used in the off-season, and in times of low sport-specific training to help maintain the high levels of anaerobic fitness.

James Marshall

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Grappling with success – lessons to be learned from wrestling strength training

Freestyle wrestling is a demanding sport that requires careful attention to strength conditioning. However these techniques are equally applicable to other weight category sports, such as judo and boxing.

Introduction

With few exceptions, success as an athlete requires the development of an appropriate and effective resistance training strategy. The appropriate programme design requires a careful analysis of the demands of the activity or activities to be targeted *(see box overleaf)* and to be effective, any programme must also follow a general periodisation model and incorporate training principles such as specificity and progression.

Demands of wrestling

A wrestling match is decided by either a fall, or if no fall occurs, by a scoring system that quantifies which wrestler is superior at controlling the opponent. Matches consist of three two-minute rounds separated by 30 seconds' rest. Competition is characterised by short-duration, high-intensity, intermittent exercise followed by periods of constant pulling, pushing, lifting and gripping movements in preparation for the next explosive effort.

The movement patterns primarily consist of grappling in order to gain dominance, so that the subsequent short bursts of effort can exploit this advantageous position. Such sparring can occur either in standing or ground positions, depending on the situation, tactics or individual strengths of the athlete.

Demand analysis

When completing an analysis of a sport for the purpose of conditioning design, consideration must be given to the metabolic and biomechanical demands of the activity. Successful athletes from the sport should be profiled in order to establish a physical and physiological template. The analysis should also consider common injuries within the sport to enable the selection of exercises that will assist with injury prevention.

Both the aerobic and anaerobic energy systems are taxed during wrestling competition. The anaerobic system provides the short, quick, all-out bursts of maximal power that characterise this sport, while the aerobic system contributes to the athlete's ability to sustain effort for the duration of the match and to recover during the brief periods of rest or reduced effort[1]. Therefore, in order to offset fatigue and maintain technique, high levels of physical fitness are necessary.

'Strength is a major component of power and therefore the blending of strength development with power-endurance development is a priority for wrestling success'

Unsurprisingly, absolute strength is typically greater in heavier wrestlers than their lightweight counterparts; however, the reverse is true for relative strength[2]. When comparing successful with less successful wrestlers or the experienced to the novice, it appears that greater strength is advantageous.

The greatest differences have been observed in the tests for upper body strength. Following rule changes in the 1970s that placed the emphasis upon aggressive wrestling and scoring over holding and blocking, dynamic rather than isometric strength has become a more crucial performance measure.

As with most combat sports, the above demands need to be analysed in the context of the restrictions imposed by weight classifications within wrestling, and their implications upon strength training and conditioning.

Competitive events are organised by weight division; optimal body composition is therefore paramount as athletes are matched by body mass and must 'make weight' prior to each event. During the season, wrestlers will attempt to maximise their lean tissue while minimising body fat and total body mass. A possible exception is the open class heavy weight division, in which additional non-force-producing body mass may provide an advantage.

Programme design must be considered within a periodisation plan that prioritises and develops the physical and physiological adaptations of the athlete as they build towards their targeted competition/s. As with most sports there are several factors that must be considered when constructing a periodised plan specific for wrestling. For example, circuit training will not increase muscular power; however, it will enhance performance when fatigue sets in. That said, attention to absolute strength and power in a non-fatigued state should not be omitted during pre- and in-season training. Strength is a major component of power and therefore the blending of strength development with power-endurance development is a priority for wrestling success.

Programme design

When designing a resistance programme for a sport, consideration must be given to variables such as volume, intensity, rest intervals and exercise selection. The goal is to manipulate these variables in a manner that targets and develops the actions that an athlete undertakes during competition, and which have been identified as crucial in the 'demand analysis'.

Wrestling programme variables

The following provides a brief overview of several types of programme variables that can be manipulated in order to best prepare the wrestler:

- **Circuit resistance training:** The main purpose of this work is to enhance the endurance capacity of the body, and key to achieving this is the management of the work:rest ratio. Typically, rest periods between exercises can begin at 90 seconds and then progress down towards 60 seconds or lower. A timeframe of four to six weeks should be allowed to make this gradual reduction, while completion of six to eight further weeks of this type of work will be needed in order to optimise adaptation. The phase of the training and the development level of the athlete will dictate the number of circuits per session (from two to five) and sessions per week (two to three). The resistances required to create the

appropriate physiological stress will range within the 10-15RM area – ie muscular failure should be reached somewhere between the 10th and 15th rep.

- **Strength training:** The above demand analysis highlights the necessity for strength development in order to optimise both attacking and defensive technique. To do this multi-joint exercises should be employed, performed with multi-planar actions – eg bench presses, lat pulldowns etc – at different angles. Compared with circuit resistance training, the rest periods are longer (two to four minutes) and require heavier loading (6RM and lower).
- **Power training:** The successful execution of wrestling technique requires the athlete to be explosive, which requires power. Again multi-joint exercises should be employed; however, now the intent is to move the mass as quickly as possible. Repetitions can range from one to six (average two to four repetitions) with loads from 30 to 40% of 1RM for higher mechanical loading to higher percentages (60-85% of 1RM) for improving power outputs at higher force levels. Adequate rest should be allowed (three minutes plus) to ensure that maximal effort can be attained. This type of resistance power training can also be supplemented by plyometric type work.

Inclusion of 'Olympic lifts' is a key component generally when aiming to develop strength and power capabilities. Their inclusion within a wrestling conditioning programme is crucial. These lifts require high levels of coordination and are very similar to throws and several other movement patterns completed during competition. The technical competency necessary to complete this type of work will also positively impact upon wrestling skills such as balance and proprioception. The inclusion of single-leg exercises can also be used to improve an athlete's ability to maintain and regain balance during competition.

Completing exercises without wrist straps or using towels and ropes should be incorporated in order to develop grip strength,

which is necessary for the successful execution of holds and throws. Body-weight exercises such as pull-ups and rope climbing are also excellent choices. However, most forearm exercises should be performed in an isometric manner in order to match the contraction type typical for wrestling.

The ability to maintain strength and power under anaerobic conditions is trainable by manipulating the order of exercises in a programme. Circuit training should be incorporated in order to develop muscular endurance, while prescribing 'Olympic lifts' or plyometric exercises at the end of a programme requires the athlete to exert high levels of power when already in a fatigued state (suggested for advanced athletes only). Longer duration (30-60 seconds) plyometric exercises or timed Olympic lifts can also help develop power endurance.

'The ability to maintain strength and power under anaerobic conditions is trainable by manipulating the order of exercises in a programme'

Core development and isometric strength

The ability to exert and withstand rotational forces is a key aspect of wrestling success. Therefore prescription of resistance exercises that target the core area (abdominals, lower back and gluteal muscles of the buttocks) is crucial to enable the efficient transfer of forces from the lower to the upper body. This type of work should generally be included in the off- and pre-season periods but may also be prescribed in technical sessions (with the coach's agreement) during the in-season.

Practically every wrestling move can have a static component and pulling and pushing moves may develop into static actions. Therefore, besides the need for isometric grip strength, the importance of isometric muscle action must be emphasised in a wrestling-specific programme. This can be completed using simple partner exercises, manual resistance or the previously mentioned rope and towel work. Again, the duration of the activity (isometric contraction) should be manipulated based on the athlete's need (greater in heavier weight categories) and on the phase of the training cycle.

Optimal gains in strength are the result of either a small number of long-duration muscle actions or a high number of shorter-duration muscle actions. Joint angle specificity must

also be considered when designing an isometric training programme. Strength will be developed only at the specific joint angle at which the exercise is performed. This must be balanced with the fact that not every joint angle can be trained because it would simply require too much time!

Body mass management

'The "programme design" considerations detailed within this article hold true for the majority of sports. The skill lies within blending these together to achieve the desired outcome'

The categorisation of athletes by weight demands high levels of strength relative to body weight. Wrestlers should therefore strive to improve maximal force and power production while retaining the ability to 'make weight'. Manipulation of volume and rest periods in resistance training plus high volume/low-intensity aerobic conditioning can play a role in addressing the issues of both weight management and body composition. This may need to be completed in conjunction with professionally designed nutrition strategy.

With the exception of the heavier weight categories, excessive muscle bulk may be undesirable in the sport. However, all athletes will benefit from improvements in body composition (increased muscle mass alongside fat loss) without altered body mass. Relative strength can be targeted by incorporating body-weight exercises (pull ups, dips, rope climbing, partner exercises, etc). As time under tension is minimal and the eccentric component negligible, 'Olympic lifts' can also be utilised without a necessary increase in body weight.

Injury prevention

Within wrestling, primary sites for upper body injuries are the shoulders, neck and elbows. For the lower body, knee-related problems are the most common. A resistance programme should aim to strengthen and stabilise the sites and structures of common injuries. In addition to muscular strength, increasing the range of motion around these joints may also help in injury prevention.

Muscular strength work with an injury prevention focus should generally be included as part of the off-season preparation phase but may also be prescribed as assistant

Wrestling-specific exercises

Strength training:
- Incline, decline or flat chest press
- Lat pull-down, pull-ups, rows
- Good mornings, dead lifts, linear/lateral lunges
- Arm curls, triceps extensions, wrist curls

Power training:
- Snatch, power clean, push-press
- Overhead/back squats
- Weighted squat jump
- 1-legged snatches or 1-arm cleans

Circuit training:
- Dumbbell shoulder press
- Lunges
- Pull-down
- Seated rows
- Core work
- Arm curls
- Squat
- Bench Press
- Deadlifts
- Hang cleans

Isometric training:
- Bear hug
- Grip strength style grips

Wrestling-specific periodisation plan

Off-season (general preparation)	• Resistance training (circuits, injury prevention, core stability) • Aerobic endurance (low-intensity/long duration)
Off-season	• Resistance training (injury prevention, core stability) • Aerobic endurance (intervals, 1:1 work/rest ratio)
Pre-season	• Maximal strength training • Anaerobic capacity (interval training)
In-season	• Muscular endurance (circuits, body-weight exercises) • Anaerobic capacity (intervals) • Power/power endurance

movements during the pre-season and in-season periods. However, wrestlers should incorporate flexibility exercises throughout the year.

Discussion

Research has highlighted the following parameters as influencing wrestling performance: body mass and composition, muscular strength, muscular endurance, muscular power, flexibility, anaerobic power and cardiovascular fitness.

These characteristics comprise the overall physiological profile of a successful wrestler. In fact it has been shown that physiological variables alone can account for up to 45% of the variance between successful and unsuccessful Olympic contenders[3]. However, it must be remembered that wrestling is a technical sport and that these characteristics form only the platform upon which the athlete must base their technical skill and strategy. Clearly it is possible for an individual to possess excellent physiological capacities and lack the sport-specific components necessary to gain competitive success.

In order to maximise the transfer of training gains, exercises selected for a sports-specific resistance programme should match the recruitment patterns and muscle actions of the activity as identified by the demand analysis. Generally the 'programme design' considerations detailed within this article hold true for the majority of sports. The skill lies within blending these together to achieve the desired outcome.

Many of the examples provided here *(see tables)* are valid for other weight category sports, most notably those involving an element of gripping and grappling such as judo and submission fighting. Some of these examples (single-leg Olympic lifts, isometric exercises, etc) may also transfer and provide benefit to other sports with similar activities such as rugby.

Andy Harrison

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Combat casualties

Be prepared at ringside I

Mixed martial arts (MMA) competition, also known as cage fighting, extreme fighting and no holds barred sport fighting, has attracted attention in recent years for its violence. Competitors wear minimal protective equipment and attempt to win the bout by: concussing an opponent into defencelessness through blunt head trauma; disabling an opponent through joint subluxation, dislocation, or soft tissue trauma; causing unconsciousness through a neck choke; or forcing an opponent into submission through a variety of the above techniques.

To date there has been limited research into the incidence and aetiology of injuries in MMA competitions. Recently Dr George Buse undertook a study to identify the primary medical issues that may be associated with MMA competition by determining the types and proportions of match stoppages ('No holds barred sport fighting: a 10-year review of mixed martial arts competition', *British Journal of Sports Medicine 2006: 40, 169-172*). Dr Buse reviewed video footage of 1,284 men competing in 642 televised matches between November 1993 and November 2003.

Based on the legal techniques and target areas, Dr Buse expected that there would be four key categories of match stoppage:

- Head impact (blunt force to the head).
- Musculoskeletal stress (joint lock, blunt orthopaedic trauma or other apparent musculoskeletal trauma).
- Neck choke (submission or stoppage due to the afflicted competitor being asphyxiated or unconscious).
- Miscellaneous trauma (other mechanisms of match stoppages not included in above categories).

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Physiotherapists	
Combat athletes	
Coaches	

Significance

Adds to previous knowledge	
Cutting edge	
Confirms best practice	
Too early to say	

How to use it

MMA competitors run a high risk of injury during matches. Medical personnel attending sanctioned matches should be aware of the main issues that they may be expected to deal with in their roles as medic or physiotherapist:

1. **Head impact** (blunt force to the head) – altered mental status, partial or total loss of responsiveness, cervical whiplash and seizures.
2. **Musculoskeletal stress** (joint lock, blunt orthopaedic trauma or other apparent musculoskeletal trauma) – acute joint damage and chronic degeneration of joints.
3. **Neck choke** (submission or stoppage due to the afflicted competitor either being asphyxiated or unconscious)
4. **Miscellaneous trauma** – eg, damage around the eyes, including cuts and nerve damage

Of the 642 matches, 182 (28%) were stopped because of head impact (punch, knee strikes, elbow strikes, kicks, slam to ground or head stomp), of which 62 (34%) involved a knockout and 120 (65%) a technical knockout. One hundred and six (16%) of the bouts were stopped because of musculoskeletal stress (elbow, ankle, shoulder and knee locks causing hyper-mobilisation of the joint through forceful distraction, hyperextension and/or rotational manipulation; and neck cranks – forceful manipulation of the opponent's head on neck). Ninety-one (14%) were stopped through the application of a neck choke and 83 (13%) because of

miscellaneous trauma. The rest of the matches ended because the match time was up or competitors were disqualified.

While mixed martial arts fighting is not a modern sport (its roots can be traced to the 33rd Olympiad in 648BC), the growth of MMA competitions in recent years has led to concerns about competitors' safety. Yet the current research is one of only a handful of studies that have looked at the mechanisms of injury during MMA bouts.

Competitors who lost as a result of one of the four key mechanisms were significantly older than their opponents, which supports the findings of previous research in which martial arts injury incidence is proportional to age. This study identified head impact as a salient medical issue in MMA competition and the proportion of matches stopped because of head impact was higher than has been documented in other full-contact combat sports (eg boxing, kick-boxing).

Be prepared at ringside II

As seems to happen, a dearth of research is followed by a crop of studies in swift succession. A US team based in Maryland has recently completed another study investigating injury in professional MMA competitions ('Incidence of injury in professional mixed martial arts competitions', *Journal of Sports Science and Medicine 2006: 136-142*). The study design differs from our first review and throws up some interesting conclusions.

Data was collected between September 2001 and December 2004 from all professional MMA events taking place in the state of Nevada, US. A total of 171 MMA matches involving 220 different competitors took place during the study period, producing 96 injuries to 78 fighters. The overall injury rate was 28.6 injuries per 100 fight participations or 12.5 injuries per 100 competitor rounds. The main findings of the study were:

- Of the 171 matches fought, 69 (40%) ended with at least one injured fighter.
- The majority of recorded injuries were to the facial region. Facial cuts were the most common injury (48%), followed by hand injury (13%), nose (10%) and eye (8%).

- After adjusting for weight and match outcome, older age was associated with significantly increased risk of injury.
- Competitors who lost a match by knockout or technical knockout ran a greater risk of injury.
- Incidence of injury increased with the length of the fight; matches lasting four or five rounds were more likely to include a fighter who suffered an injury.

In conclusion, with an overall injury rate of 28.6 injuries per 100 fight participations, MMA competitions demonstrate a high overall rate of injury, but in keeping with other combat sports involving striking.

The appliance of science

For attention of

Doctors	
Physiotherapists	
Combat athletes	
Coaches	

Significance

Adds to previous knowledge	
Cutting edge	
Confirms best practice	
Too early to say	

How to use it

This new study alerts us to both the frequency and nature of likely injuries in MMA competition. Once again, presiding medical personnel should take note:

1. As many as two out of five fights may end with at least one injured fighter.
2. Expect to have to deal with large numbers of facial injuries.
3. Older competitors are more likely to end up hurt .
4. Competitors who lost a match by knockout or technical knockout have a high risk of injury.
5. Competitors who last 4 or 5 rounds are more likely to sustain an injury.

Kinder Karate

Is a modern non-contact form of karate a safer alternative to some of the more supposedly high risk forms of martial arts? Karate is often cited as a sport with a high risk of injury. In 2000 the World Karate Federation changed the rules of competition in an effort to promote the sport, decrease injury rates, and make competitions more dynamic and attractive. The purpose of this study was to evaluate the incidence and distribution of injuries in Karate before and after the implementation of the new rules and safety standards ('Effects of new karate rules on the incidence and distribution of injuries', *British Journal of Sports Medicine 2006: 40, 326–330*).

The study covered 887 karate matches during 1997 and 1,604 in 2002. In 1997 the overall injury incidence was 10.28 per 100 exposure minutes. In 2002 the incidence was 9.82 per 100 exposure minutes. In both periods women over 18 years of age showed the highest injury incidence while men over 18 years of age showed the lowest injury incidence. In 1997 there was a higher risk of sustaining a head injury but in 2002 there was a higher risk of leg injury.

It was thought that women were more vulnerable to injury because of their generally lower levels of technical and tactical skills and lesser competition experience. The increase in leg injuries can be linked to changes in the scoring system that placed an increased emphasis on kicking techniques. The study concluded that the relative risk of injury for young competitors was significantly reduced, and this could be related to the implementation of the new rules and safety standards, including protective equipment (compulsory gum shields and standardised size and shape of gloves), light contact rules of engagement and mandatory medical supervision.

Female competitors and younger competitors in other sports, both martial arts and other contact sports, have been shown to be at higher injury risk, so governing bodies could use these findings to take stock of the potential to improve their own rules and safety standards.

The appliance of science

For attention of

- Martial arts coaches and competitors 
- Doctors 
- Physiotherapists 

Significance

- Adds to previous knowledge 
- Cutting edge
- Confirms best practice
- Too early to say

How to use it

- Previous research has shown that the most common site of injury in karate is the head, but severe injuries are rare.
- Current findings suggest that there has been an overall drop in the number of head injuries.
- The implementation of new rules has significantly lowered the relative risk of injury.
- The more frequent use of kicks since rule changes may explain the increased incidence of leg injuries.
- Female competitors run a higher risk of injury compared to male competitors.

Nick Grantham

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