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MASS-12: EVIDENCE-BASED MARTIAL ARTS STRIKING SPORTS INJURY PREVENTION PROGRAMME

ABSTRACT

Much study focuses on the effects of unavoidable injuries in sparring (i.e. contact injuries). However, the majority of martial arts injuries occur during training, rather than competition. Many common martial arts injuries, from ligament tears to ankle sprains, could be prevented with appropriate prehabilitation. With an emphasis on tradition, recreational martial arts clubs have not yet widely adopted modern prehabilitation exercises, which are particularly crucial given the higher rates of preventable injuries in the female athlete and national efforts to increase participation of women in sport. We reviewed the literature to identify injury prevalence and mechanism in martial arts striking sports (MASS). Given the lack of data on female martial artists, we also reviewed common injuries in female athletes engaging in high impact sport. We then identified sport-specific evidence-based interventions using a combination of literature review and Physiotec exercise video library and filtered this through the constraints of recreational martial arts environments to develop a cohesive, useable prehabilitation programme for MASS. We propose a programme of 12 exercises for injury prevention in martial arts striking sports (MASS-12). We emphasise the importance of biomechanical retraining to ameliorate the heightened risk in the female athlete while targeting common injuries across all sexes in martial arts. Hip-knee-ankle alignment is key to injury prevention in MASS, while improved injury surveillance across recreational MASS is needed for future intervention.

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KEYWORDS

Injury prevention; female athlete; ligament; martial art

Accepted for publication on 1 June 2024



Abbreviations

- ACL:** anterior cruciate ligament
HKA: alignment: Hip-knee-ankle alignment
MA: Martial arts
MASS: Martial Arts Striking Sports
MTSS: Medial Tibial Stress Syndrome
SUI: Stress Urinary Incontinence

INTRODUCTION

Contrary to popular belief, the majority of martial arts (MA) injuries – even in higher risk styles such as Mixed Martial Arts – occur during training, rather than competition (Jensen et al., 2016).

MA training typically involves high impact activities like jumping, cutting and pivoting; movements which are all known to significantly increase the risk of musculoskeletal injury (Hewett et al., 2016). Knee ligament injuries, such as tearing of the anterior cruciate ligament (ACL), are nearly 80% more likely to occur during a high-risk movement, such as landing or cutting, rather than direct contact (Voskanian, 2013). Despite this, there is little mention of ‘non-contact’ injuries within the studies evaluating the types of injuries sustained during MA training (Jensen et al., 2016; Thomas & Thomas, 2018), with most only evaluating those injuries sustained during competition due to challenges in recreational injury surveillance.

Female athletes are at higher risk of injuries in sport. Knee ligament injuries are up to six times more likely to occur in females than males (Hewett et al., 2010) and overuse syndromes such as shin splints (Medial Tibial Stress Syndrome or MTSS) and heel pain (plantar fasciopathy) are seen with far greater frequency in female athletes engaging in high impact sports compared to their male counterparts (Koester, 2000; Thacker et al., 2002). Young female athletes may also experience stress urinary incontinence (SUI) during high impact activities (Casey & Temme, 2017). Incontinence may not only be a potential barrier to participation – particularly in an environment such as MA where the uniforms are often white – but if coaching staff are not aware of the need to train young female athletes to strengthen their perineal muscles, the high intra-abdominal pressures of their sport may overload and chronically damage the perineum, increasing their risk of developing SUI. In MA training, there is a strong emphasis on training everyone together regardless of age or sex, therefore an understanding of female-specific issues is vital for coaching safely and successfully. However, coaching without consideration for the physical issues affecting females will leave them at high risk of injury.

Training methods which include proper sport-specific preparation, for example teaching plyometric movements in a sport where jumping is a requirement, play an important role in the prevention of musculoskeletal injuries (Koester, 2000). All

coaches, therefore, should have a good knowledge of the common injuries associated with their sport and preventative measures they can introduce to protect their students. The impact of a clear, sport-specific injury prevention resource was most famously shown by the 30-70% injury rate reduction in football players adhering to the world-renowned FIFA 11+ programme (Barengo et al., 2014). Although martial arts – particularly Martial Arts Striking Sports (MASS) such as Taekwondo or Karate – training involves many movements identified as ‘high risk’ for injuries (cutting, jumping and landing) (Bisciotti et al., 2019), there is no published evidence-based preventative programme specific to recreational MASS. Therefore, in this study we build on the success of the prehab model demonstrated by the FIFA 11+ programme to provide the first evidence-based injury prevention protocol specific to MASS.

DEVELOPMENT OF THE MASS-12

The sequence of prevention for sports injuries is modelled by the need to “establish the extent of the sports injury problem”, “establish aetiology and mechanism of injury” and “introduce preventative measures” (Van Mechelen et al., 1992). We applied this idealised model to the current need for evidence-informed programmes for recreational MASS athletes. First, we reviewed the literature to identify trends in injuries in MASS athletes as well as injury mechanisms. Despite numerous reviews on this topic, the limitations of injury surveillance in a recreational setting – namely the lack of specificity in identifying injuries beyond general location (i.e. foot) or type (i.e. sprain) – made defining specific injury trends challenging. We therefore focused on the most common non-contact injuries sustained during high impact sports, leveraging the wealth of literature on preventable injuries particularly in the female athlete.

Then, through a combination of literature review and the database of exercises developed by Physiotec (<https://physiotec.ca/ca/en/>), we identified exercises that were proven to prevent such injuries. We characterised the recreational martial arts environment, noting potential limitations and challenges to actualising any prehabilitation programme. Finally, we filtered down the exercises to a time-efficient programme organised in line with the Raise, Activate & Mobilise, and Potentiate (RAMP) warm up protocol (Jeffreys, 2007). We excluded mixed martial arts due to the significant inclusion of grappling based movements, which display distinct movement mechanics and injury profiles from MASS.

MASS INJURY TRENDS & MECHANISMS

Five reviews of martial arts injuries were investigated to identify injuries potentially prevented through prehabilitation (Bromley et al., 2018; Demorest et al., 2016; Koutures & Demorest, 2018; Pieter, 2005; Thomas et al., 2017). MASS athletes experienced high rates of head and lower limb injuries. Foot, head, and hand injuries were attributed to contact-based mechanisms (Pieter,

2005), and were thus excluded from this programme development as they are unlikely to be avoided through prehabilitation programmes. Performing kicks was identified as a common injury cause, leading to high numbers of sprains and lower extremity injuries in both contact and non-contact MASS. While not

defined here as a MASS, within boxing, the ‘boxer’s elbow’ – hyperextended elbow – is caused by missing a target with a punch (Valkering et al., 2008), a movement pattern that also exists in MASS such as Karate. We therefore also included this in our injury target list (Table 1).

Table 1

Overlap of common injury sites in MASS and common injuries in female athletes in high impact (HI)

Injury location in MASS	Injuries in both MASS & female athletes in High Impact Sports	Injuries in female athletes in High Impact sport only
Knee	Knee ligament tears (Toth & Cordasco, 2001) Patellar tendinopathy (Grau et al., 2008)	Incontinence (Rortveit et al., 2003)
Hip	Hip impingement (Nakano et al., 2017)	Stress urinary incontinence (Joseph et al., 2021)
Ankle	Ankle sprains (Hosea et al., 2000)	Back pain (Fett et al., 2017)
Foot	Plantar fasciopathy (Scher et al., 2009)	*Hypermobility (Quatman et al., 2008)
Hamstring	Shin splints (MTSS and stress fractures) (Dugan & Weber, 2007; Reinking et al., 2017; Thacker et al., 2002)	*Knee valgus (Kirkendall & Garrett, 2000; Utturkar et al., 2013)
Groin		
Elbow		

*Hypermobility and knee valgus are not injuries, but risk factors for musculoskeletal injury

Reviews of MASS injuries included numerous calls for improved injury surveillance. Injury studies are generally either survey based – suffering from selection bias and depending on recollection of participants – or competition-based – suffering from a lack of clinical detail or long-term impact. Ultimately, this leads to vague terminology such as ‘lower extremities’ or ‘knee’ rather than clear injury locations and types such as ‘ACL tear’.

Despite the low numbers of female athletes in these studies, female athletes were noted to experience higher rates of injury per hour of athletic exposure than their male counterparts (Pieter, 2005; Thomas et al., 2017). Female athletes are known to experience higher rates of non-contact injury than their male counterparts when engaging in high impact sport, and these injuries are by definition largely preventable through prehabilitation. We therefore reviewed injury trends in female athletes taking part in any high impact sport, noting injury cross-over with MASS injury locations (Table 1). We then mapped injury causing movement patterns (Bisciotti et al., 2019) back to common movement patterns in martial arts (Table 2). Indeed, delivering a kick in MASS, a commonly cited injury causation mechanism, often involves cutting (to get a good angle on an

opponent or to dodge and offer a counterattack), jumping, landing, contact and decelerating momentum – all identified as high-risk injury mechanisms in sport.

IDENTIFYING EVIDENCE-BASED PREVENTATIVE EXERCISES

For each common injury, we identified research-proven preventative exercises through a combination of literature review and the Physiotec exercise video library. We initially generated a list of over 40 evidence-based exercises that focused on dynamic mobility of the spine, hip, and ankle; eccentric training of the adductors and hamstrings; core strength and control; gluteal strength; balance; proprioception and plyometrics. To ensure usability, we created a table of common challenges and limitations for exercises in a recreational MASS environment (Table 3) and used this to exclude exercises that were not feasible, such as those containing equipment. Where multiple exercises were available to address an injury, we chose the exercise that overlapped the most injuries to make the shortest list, and then the exercises that most mimicked common martial arts movements. Finally, we adapted

the resulting 'potentiate' level exercises to prepare the athletes for sport-specific movement patterns.

Table 2
Common movement patterns in MASS known to be mechanisms for injury

Common injury mechanisms	Correlating martial arts movement
Rapid changes in direction	Dodging or delivering attacks during sparring
Pivoting	Kicking
Landing	Jump-kicking
Pivoting & landing	Jump-spin kicking
Elbow hyperextension	Punching

Table 3
MASS training setting challenges for implementing modern exercise guidelines in a recreational setting

MASS setting characteristic	Challenge
Diverse ages, commonly 6-70	Children and adults engage with activities differently
Diverse class sizes, 4-30 students per coach	Coaches cannot easily provide 1-1 explanation or feedback
Diverse student experience level	Experienced students can get bored listening to novice level instructions
Diverse body types	Students can feel alienated by exercises they cannot perform Coaches must be trained to recognise good form across body types
Loose-fitting traditional uniforms	Loose-fitting uniforms can disguise poor mechanics
Time	Recreational sessions may last only one hour
Equipment	Standard physiotherapy equipment (resistance bands, weights, balance boards) are not available
Bare feet	Bare feet landing reduces shock absorption, increasing impact on joints
Recreational attendance	Students may only attend a session once a week

Table 4

The MASS-12 warm up programme for injury prevention

Includes named exercises and their clinical rationale for inclusion.

#	Name <i>Muscles targeted (if any)</i> Purpose	HKA?	Martial skill	R A M P
	Injuries prevented (if any)		Difficulty level	
1	Running drills (low-impact, multi-directional, quick-change, side-shuffles) <i>General increase in blood flow to all muscles</i> Raise soft tissue temperature; reactive neuromuscular control; balance and proprioception	No	Agility & Evasion	R
	Increase general tissue extensibility and lower limb joint mobility		*	
2	Lunge walking (half-way and full) <i>Quad, Glutes, Hamstrings</i> Reactive neuromuscular control; balance; proprioception; functional strength training; dynamic alignment; joint mobility	Yes	Split stance; Kicks	
	Plantar fasciopathy; MTSS; ACL injury; patellar tendinopathy		***	
3	Heel walking <i>Tibialis anterior, Extensor Halluces Longus</i> Functional strength training (ankle); balance and proprioception	No	Barefoot training	
	MTSS		*	
4	Toe walking <i>Calf complex, quads</i> Functional strength training (ankle); balance and proprioception	No	Barefoot training	A M
	Plantar fasciopathy, ankle sprains		*	
5	Dynamic stretching (Figure- 4;spinal roll-down; Cossack squat; Shin Box; Downward Dog walking) <i>Hip mobility, Spinal mobility - flexion, hamstring flexibility, Ankle mobility - dorsiflexion</i> Spinal, hip, and ankle mobility; soft tissue flexibility; balance and core strength; hip strengthening (eccentric adductors)	No	Kicks	
	Groin strain, mechanical low back pain, knee pain, hip pathology including impingement, plantar fasciopathy, MTSS		**	
6	Side-plank with inner thigh raise & Copenhagen Plank exercise <i>Adductors, gluteals, hamstrings, pelvic floor, scapular stabilisers, rotator cuff, abdominals</i> Hip strengthening (adductors), core strength, shoulder stability	No	Sweeping, inward kicks	A M
	Groin strain, ankle sprain, SUI		**	

7	Plank with scapular press-up <i>Abdominals, scapular stabilisers and rotator cuff</i> Core strength; static alignment	No	Punches	
	Elbow hyperextension, subacromial pain syndrome, mechanical low back pain		***	
8	Wide squats with forefoot control <i>Quads, glutes, hamstrings, pelvic floor</i> Hip and pelvic floor strengthening; balance and proprioception; dynamic alignment; joint mobility (hip) and soft tissue flexibility; priming sport-specific muscle activity; reactive neuromuscular control; increase tissue resilience to loading	Yes	Jump kicks	
	SUI; patellar tendinopathy		**	
9	Single leg deadlift (Assisted/unassisted, with/without hip rotation, with/without mini-squat) <i>Abdominals, hamstrings, quadriceps, gluteals, erector spinae</i> Core & hip strength; balance, proprioception; dynamic alignment; joint mobility, soft tissue flexibility; priming sport-specific muscle activity (eccentric hamstring muscle strengthening); reactive neuromuscular control (sport-specific movement pattern)	Yes	Kicks	
	Hip impingement; hamstring injury; knee ligament tears, ankle sprain, mechanical low back pain, patellofemoral pain		***	
10	Star Excursion with pivot shift on ball of foot (with or without foot touching floor) <i>Glut med; Calf, quads</i> Core and hip strength; balance and proprioception; dynamic alignment; joint mobility and soft tissue flexibility; priming sport-specific muscle activity (synergy of quadriceps and hamstrings); reactive neuromuscular control (sport-specific movement pattern)	Yes	Balance, pivot kicks	P
	Ankle sprains; knee tears, patellar tendinopathy		***	
11	Jumps (tuck, with/without rotation 90° – 360°, and/or single leg) <i>Complex lower limb integrated movements</i> Calf strength; balance and proprioception; dynamic alignment; joint mobility and soft tissue flexibility; priming sport-specific muscle activity (coordination of the quadriceps and hamstrings for landing control); reactive neuromuscular control; increase tissue resilience to loading	Yes	Jump kicks	
	Ankle, knee, tendinopathy, plantar, Achilles tendinopathy, shin splints		***	
12	Lunge with contact (or single leg hold with contact) <i>Complex lower limb integrated movements</i> Hip and core strength; balance and proprioception; dynamic alignment; joint mobility and soft tissue flexibility; priming sport-specific muscle activity; reactive neuromuscular control; increase tissue resilience to loading	Yes	Contact	
	Contact injuries		**	

HKA: Hip-knee-ankle alignment; RAMP: Raise, activate and mobilize, potentiate; MTSS: Medial Tibial Stress Syndrome; SUI: Stress urinary incontinence.

STRUCTURING THE PROGRAMME

Twelve exercises were selected to create a time-efficient programme (Table 4) with adaptations for sport-specific movement patterns. We structured the program in line with the Raise, Activate/ Mobilise and Potentiate (RAMP) warm up protocol (Jeffreys, 2007). The movements roughly divide into sport-specific strength training, functional mobility, and neuromuscular control to reduce the risk of non-contact injuries based on the identified injury mechanisms. We emphasised a particular focus on improving hip, knee, and ankle (HKA) alignment as a proven strategy to reduce lower extremity injuries (Nessler et al., 2017). Embedding good HKA alignment was critical to the programme both in its contents and in the coaching cues recommended.

THE MASS-12 WARM-UP PROGRAMME

We describe here the MASS-12 programme and the rationale for each of its movements

Raise

Low intensity exercises which elevate the heart and respiratory rate were included in the first phase of the MASS-12, essentially increasing blood flow to get oxygen and glucose to the muscles more quickly. The resulting increase in muscle temperature also improves metabolism and the speed of nerve conduction (Pearce et al., 2012), allowing muscles to contract more efficiently and respond more rapidly. The 'Raise' exercises included in the MASS-12 are chosen not only to generally raise physiological indicators, but also to introduce the sport-specific neuromotor skills required for MASS such as initiating movement, directional change, transitional movements, acceleration, and deceleration. Lunge walking, heel walking and toe walking were also included to cover some key movement patterns and balance skills.

Activate and Mobilise

In this second phase, we include exercises with the aim of moving the body dynamically through the ranges of movement required for MASS and functionally strengthening specific movement patterns relevant to MASS, thus reducing the risk of injury, and improving performance. Dynamic mobility of the spine, hips and ankle joints, strength in the posterior chain (including gluteal muscles, hamstrings, adductors and calves) and core strength are key components in this phase of the warm-up for injury prevention (Bizzini & Dvorak, 2015).

Static stretching - including box splits - is traditionally completed at the beginning of a MASS session as part of a warmup (Monoem, 2014). However, modern exercise theory suggests that static stretching like this prior to sport does not prevent injury (Pope et al., 2000) and dynamic stretching is more widely advocated. While static stretching may produce the desired

increase in flexibility, it also impairs the athlete's ability to absorb and store kinetic energy – required for sudden speed or power – making them less efficient and potentially more injury-prone. Dynamic stretching, however, has been shown to improve joint range of motion without changing the passive mechanical properties of the muscle-tendon unit (Mizuno & Umemura, 2016), so it will not impede performance and may also reduce the potential for injury (Holt & Lambourne, 2008; Wilson et al., 2010). Thus, we include dynamic hip, ankle and spinal stretches within the MASS-12 warm up programme and suggest static stretching be completed at the end of a training session.

MASS training requires a good level of spinal and hip mobility for head-height kicks. Sports which require high spinal loading increase the potential risk of acute traumatic sprains, strains, and persistent overuse injuries (Kesson & Atkins, 2005). Even spinal movement prevents excessive load falling on one area of the spinal column which otherwise has the potential to cause segmental microtrauma and back pain (Heneghan et al., 2020), a common injury for women in high impact sports. Limitation of hip mobility is also associated with low back pain, along with labral tears, groin strain and osteoarthritis of the hip and knee (Reiman & Matheson, 2013). Thus, we include a spinal roll down (the Jefferson curl) and three dynamic stretches for the hip joints: the Figure 4 stretch, Shin Box and Cossack squats.

A loss of ankle mobility (dorsiflexion) is linked with impaired balance and the potential for ankle sprain, along with a greater risk for patellar tendon injury in sports which involve jumping (Malliaras et al., 2006). Associated tightness in the calf complex or Achilles tendon also increases bony overload and the development of MTSS (Beck, 1998) and strain in the plantar fascia, with the potential to develop plantar fasciopathy (Riddle et al., 2003). Reduced dorsiflexion is also strongly associated with greater collapse of the knee into valgus (Wilczyński et al., 2020). This movement pattern on squatting to jump or landing is widely identified as a significant predictor of knee ligament injury. As jump kicks or strikes form an integral skill set in some MASS, the inclusion of an exercise to improve or maintain ankle mobility was also vital. Thus, we include the Downward Dog Walk.

Strength training is vital for control, balance, attenuation of forces and optimal joint placement of the lower limb joints. Its inclusion as part of a successful injury prevention programme is universally accepted but it is especially important when working with mixed groups as the prevalence of joint hypermobility is higher in women than men (Quatman et al., 2008). Resistance training movements which mimic the movement patterns required for activity (dynamic functional training) leads to greater training gains in strength and endurance than traditional strength training (Da Silva-Grigoletto et al., 2019). Therefore, where possible, we incorporate functional strength training using MASS mechanics over traditional strength training in the MASS-12.

Strengthening the hip musculature may reduce the risk of ACL injuries on jump landing in women by reducing the

biomechanical factors which increase their risk of injury (knee valgus) (Stearns & Powers, 2014). Core strengthening has similar outcomes by improving alignment of the knee in the frontal plane (Larwa et al., 2021). Combining hip and core strengthening exercises within a programme together therefore reduces the risk of lower limb overuse injuries (Niemuth et al., 2005; Thijs et al., 2007) and also the risk of groin strain, which is higher in male athletes (Tyler et al., 2001). Thus, we include the plank and Copenhagen plank within the MASS-12 programme.

Hip and knee strengthening together is more effective in preventing lower limb overuse injuries than hip strengthening alone, so wide squats were included to increase strength of both the quadriceps and hamstrings. Strength in these muscle groups is also important for good pelvic floor health. Wide squats are more challenging for the pelvic floor compared to narrow squats, so education for correct coaching for this exercise is key. A variation including one leg heel lift was included to improve the forefoot control and balance required for pivot kicks during MASS training.

Single leg deadlifts with a MASS modification were included to increase eccentric hamstring strength to reduce the risk of hamstring strains (Tyler et al., 2017), to activate the hamstrings to increase knee stability and assist the ACL to stabilise the knee (Cowling & Steele, 2001; Solomonow et al., 1987), and to prepare the student for kicking movement patterns. Single leg deadlifts also challenge balance and strengthen the lower calf muscles (triceps surae). Improving strength in the triceps surae means the student is less likely to fatigue during training which protects against an increase in the load on their tibia and the potential to develop MTSS (Beck, 1998). Better calf strength also reduces the risk of developing Achilles tendinopathy (Mahieu et al., 2006) while improving strength and control around the ankle reduces the risk of ankle sprain (Osborne & Rizzo, 2003).

Potentiate

Exercises to stimulate fast neural response to prepare the student for higher impact and more explosive forces are included in this final phase of the MASS-12. Balance, proprioception, jump mechanics, partner contact and overall mechanical alignment help the body to efficiently and quickly respond safely to extrinsic factors such as an uneven floor surface, contact from a partner, or landing a kick (Dugan & Weber, 2007).

Acute and overuse injuries in many sports, including soccer and basketball which contain similar agility and jumping movement mechanics to MASS, have been reduced through functional balance training (Soligard et al., 2008). In particular, frontal and transverse foot-ankle motion is key for injury risk reduction (Delahunt & Remus, 2019). Thus we use a modified star excursion exercise to train functional stability of the ankle joint, trunk proprioception, and precise control of the knee in the frontal plane, reducing the risk of ankle sprain (Chaiwanichsiri et al., 2005) and knee ligament injury (Delahunt & Remus, 2019; Trojian & McKeag, 2006).

Dynamic control, directional change and jump technique are trained with tuck jumps to increase soft tissue resilience and facilitate the fast, powerful responses needed to meet the demands of MASS training. We emphasize the need for coaches to educate their students on the importance of careful HKA alignment for both take-off and landing to reduce the risk of ACL injury (Cowling & Steele, 2001). The 'drop and hold' teaching method encourages students to check and self-correct their take-off or landing HKA alignment. Finally, preparation for contact is trained with increasing intensity with a partner in a sport-specific position.

COACHING RESOURCES

Strengthening alone will not prevent injury (Nessler et al., 2017). Good mechanics and neuromuscular control is critical (Hewett & Myer, 2011). Hence, we have placed a strong emphasis on educating coaches to improve a student's dynamic alignment and successfully implement this multifaceted programme. Therefore, we included an informative coaching reference with this study (Appendix A), which contains teaching phrases for coaches to describe good technique. We noted where coaches should pay particular attention to HKA alignment, and identified which exercises are more difficult to perform well and thus may require more time initially to ensure good form (Table 4).

DISCUSSION

We provide here a unique and practical approach to using available literature to identify injury trends and preventative exercises to build a prehabilitation programme. Such programmes must be moving targets as recreational injury surveillance – and thus research – improves with time. Alongside the wealth of literature defining preventative exercises; the exemplar of the highly successful FIFA-11+ programme; and the inclusion of practitioner insights on logistical limitations and target movement patterning, it is possible to create and refine sport-specific, evidence-informed prehabilitation programmes.

A successful and effective warm up should prepare athletes mentally and physically for their sport. It should be practical for the instructor and enjoyable for the students, and where appropriate include sport-specific movement patterns for optimal impact (Sadigursky et al., 2017; van den Tillaar et al., 2019). Prehabilitation programmes depend on repetition to develop unconscious competence (mastery) of efficient movement patterns and can also act as a psychological cue to the athlete, so they are mentally prepared to engage with training.

A key feature of injury prevention in MASS, high impact sport in general, and particularly the female athlete is HKA alignment to prevent knee valgus loading. Visually assessing alignment is difficult - in one study, 66 physiotherapists agreed only 60-80% of the time in evaluating knee-pelvis alignment, despite being highly familiar with analysing movement and alignment in their clinical practice and being able to see the movement three times on the

computer (Whatman et al., 2013). We imagine such alignment would be substantially more difficult to address when teaching 20 students at a time, or where students wear oversized trousers as is common in MASS. It may be that proven phrases such as “land softly” (Laughlin et al., 2011) or mental imagery, i.e. “Imagine your perfect jump” prior to executing a technique may be key for students to self-address such alignment. Creativity in a MASS context, such as holding a wooden staff vertically at the knee as a form of biofeedback, may additionally help students self-correct.

Finally, we echo the findings of the reviews cited in this study, calling for improved record-keeping on training injuries in MASS athletes. Injury recording in recreational sport is inconsistent, and follow-up data of injuries to a clinical diagnosis (thus distinguishing a minor sprain from a significant ligament tear) is rarely, if ever, available. Indeed, the trajectory of injury and return to sport in a recreational context would be of particular interest, in quantifying both the injury trends and experience of MASS athletes. Such significant infrastructure improvements both in MASS and in recreational sport in general would undoubtedly lead to even more targeted prehabilitation programmes in MASS and, indeed, recreational sport at large.

CONCLUSION

Here we propose the first evidence-based injury prevention programme for recreational martial arts, the MASS-12, which takes into account the recreational training environment. This work will benefit coaches through its practical approach to describing the science behind this targeted approach, and athletes through the reduction in training injuries.

Appendices

Coaching poster for MASS-12 (see below)

Coaching handbook for MASS-12 (see below)

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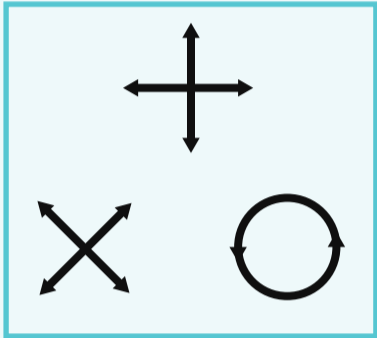
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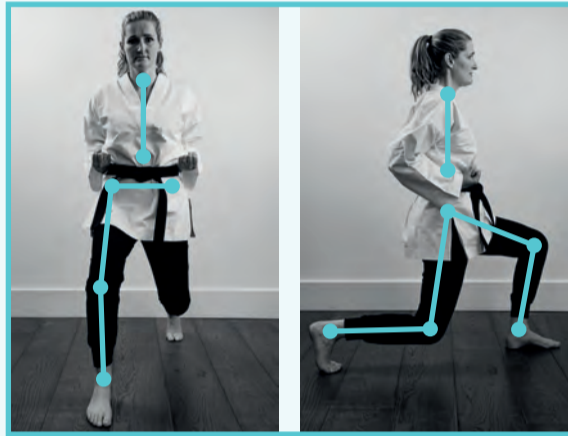
Warm-up Programme for Injury Prevention in Martial Arts

RAISE up to 5 minutes

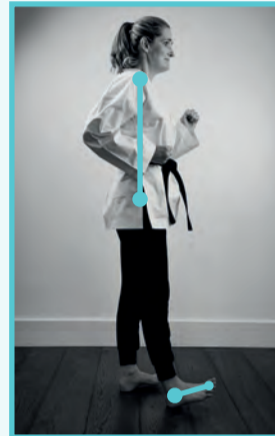
1 Running Exercises



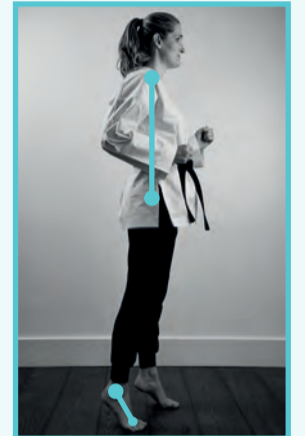
2 Lunge Walking



3 Heel Walking



4 Toe Walking



ACTIVATE/MOBILISE 5 minutes

5 Dynamic Stretching



6 Side Planks



7 Plank with Scapular Press-up



8 Wide Squat with Forefoot Control



POTENTIATE 10 minutes

9 Single Leg Deadlift



10 Star Excursion with Pivot Shift



11 Jumps



12 Lunge with Contact





**Warm-up Programme for Injury Prevention
in Martial Arts**

The Programme

The MASS-12 is the first evidence-based injury prevention programme designed specifically for Martial Arts Striking Sports (MASS). It includes 12 practical warm-up exercises that will prepare students mentally and physically for their training, and includes sports specific movement patterns to help prevent injuries and improve performance.

Good form is vital for the success of this programme – proper alignment of the trunk, hips, knees and ankles is a key component of good form. So, coaches should be familiar with and able to identify the common issues associated with injury, in particular the ‘knee valgus’ position (knee buckling inward). Each exercise is shown with the common alignment faults for clarity, and a three-star system is used to identify those exercises which may take time to master with good form.

Coaches should aim to progress from correcting their students’ alignment, to teaching their students how to identify their individual alignment issues, so they can self-correct instead.

A slow pace and low number of repetitions are recommended initially so that students can focus on proper technique. Some exercises require less explanation, but those exercises with a triple star are expected to take longer for students to master and may require more time for teaching and correction.

When students are familiar with the exercises and can perform them properly, the speed, intensity and number of repetitions can be raised. It may take up to eight training sessions before students are able to complete all exercises in the MASS-12 correctly.

Teaching Tips

- Explain the exercise and demonstrate with verbal cues for good technique.
- Ask students to copy while you are demonstrating.
- Once they are familiar with the exercise, observe technique and provide individual or group correction.
- Some exercises include higher level variations. Students should only progress to these variations if they can perform the lower-level variation with great form and without any difficulty.

RAISE Exercises



up to 5 minutes

This part of the programme includes low intensity exercises which raise the heart and respiratory rate.

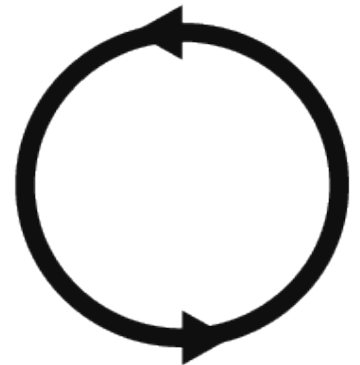
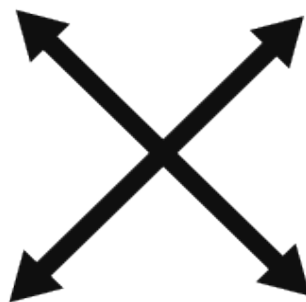
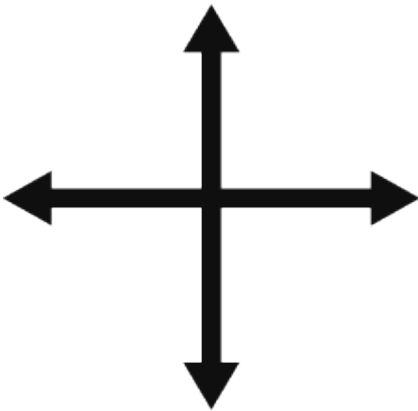
1. Running Drills



These drills increase tissue temperature and will challenge your students' balance, control, agility and efficiency.

Start with a gentle pace and instruct your students to be aware of maintaining an upright torso and good hip, knee and ankle (HKA) alignment throughout.

Include directional changes, side shuffles, backwards running and stop/start patterns after the first few minutes.



2. Lunge Walking



The goal of this exercise is to introduce MASS specific movement patterns with careful control of HKA alignment. This exercise should be completed with enough pace to maintain the increase in tissue temperature established during the running drills.

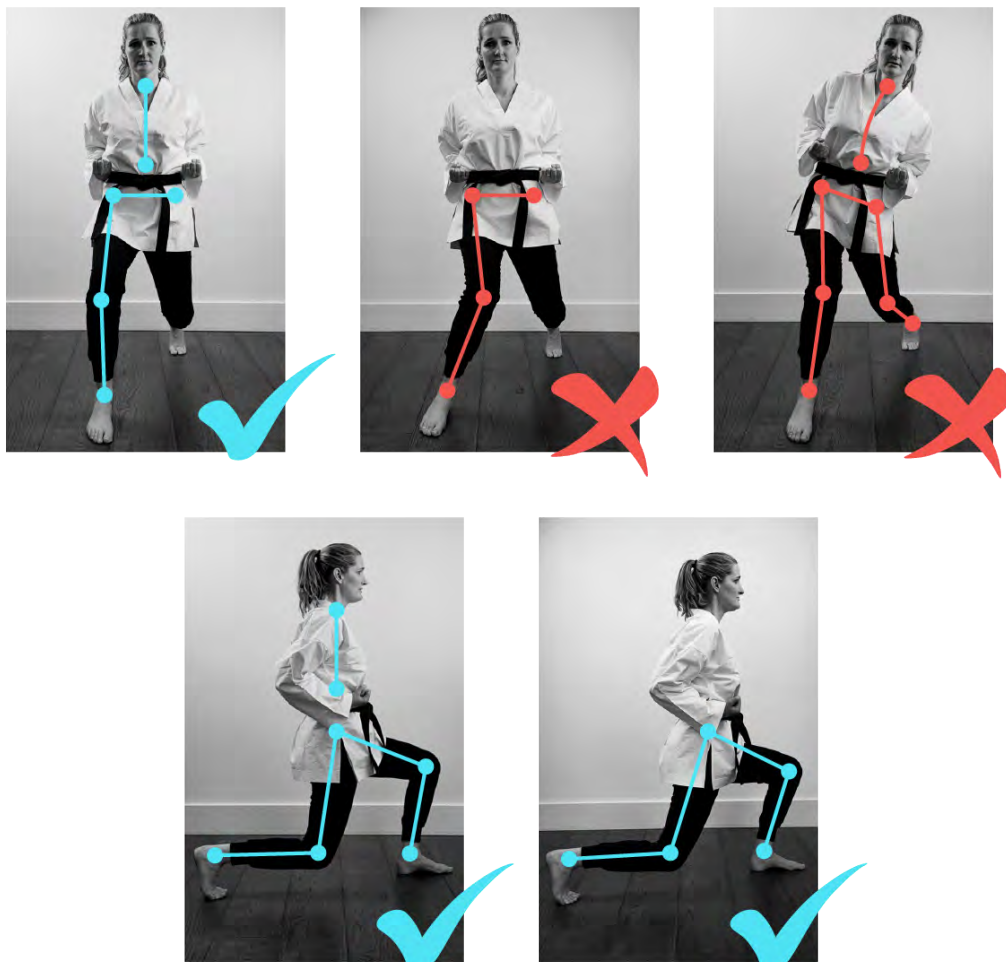
The depth of the lunge walk can be increased for more experienced students to increase the challenge. Include directional changes and the occasional instruction to 'drop, hold and check', so students can look down and learn to self-correct their HKA alignment.

Instructions

- Stand with your feet hip width apart, take a step forward and bend your knees to lower your back knee towards the floor.
- Push down through both legs to straighten again and step the back leg forwards.
- Start the lunge on the opposite side and repeat.

Key Teaching Points

- Keep your torso upright and facing forwards.
- Keep your pelvis upright, level and facing forwards.
- Keep your front knee in line with your front foot, it is fine for the knee to move in front of the ankle joint.



3. Heel Walking



This exercise strengthens the muscles at the front of the shins, helps to maintain good ankle range of motion, and starts to challenge balance and control.

This exercise should be completed with enough pace to maintain the increase in tissue temperature established during the running drills. Add in directional changes and backwards walking to gamify.

Instructions

- Start with your feet hip width apart and flex your ankles, so your toes are off the floor.
- Walk forwards, keeping your toes off the ground, balancing on your heels.

Key Teaching Points

- Stay upright and keep your eyes on the horizon.
- Keep your toes off the ground and pointing forwards.
- Keep your bottom tucked in.



4. Toe Walking



Toe walking strengthens all muscles in the legs, while also working on balance and coordination.

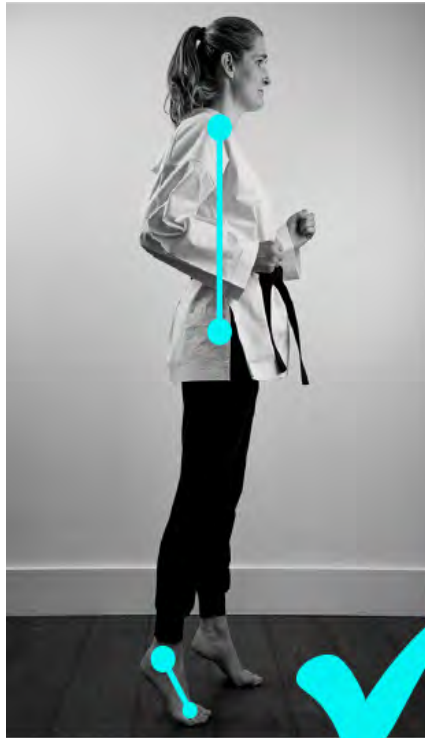
This exercise should be completed with enough pace to maintain the increase in tissue temperature established during the running drills. Add in directional changes and backwards walking to gamify.

Instructions

- Start with your feet hip width apart and press down with your toes to raise your heels.
- Walk forwards, balancing on your toes.

Key Teaching Points

- Stay upright and keep your eyes on the horizon.
- Walk on your toes with your heels as high as possible.



ACTIVATE/MOBILISE Exercises



5 minutes

This part of the programme includes exercises which move the body dynamically through the ranges of movement required for MASS. These exercises will also functionally strengthen specific movement patterns relevant to MASS.

5. Dynamic Stretching

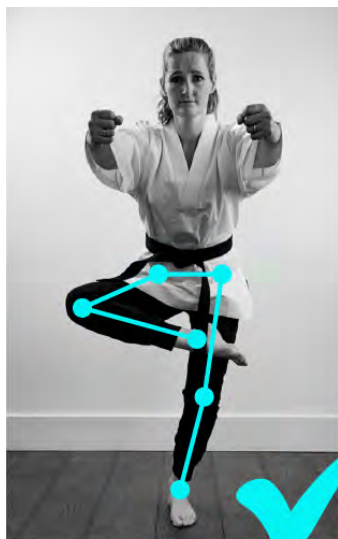
All five stretches move the body dynamically through a range of movements needed for MASS (hip mobility, even spinal motion and ankle flexibility).

Standing Figure-4

- Bend your knee slightly and place one foot just above the opposite knee.
- Hinge at your hip and lower into a single leg squat until you feel a stretch in your buttock muscles.
- Bend and straighten your support leg a bit (not fully) while holding the stretch, 15 – 20 times.
- Repeat on the other side.

Key Teaching Points

- Keep your spine straight.
- Aim the base of your pelvis up slightly.
- Keep the knee of your support leg in line with your toes.

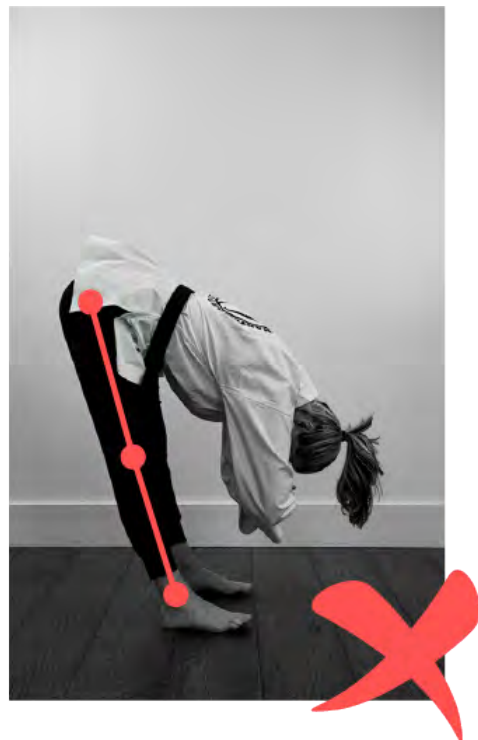
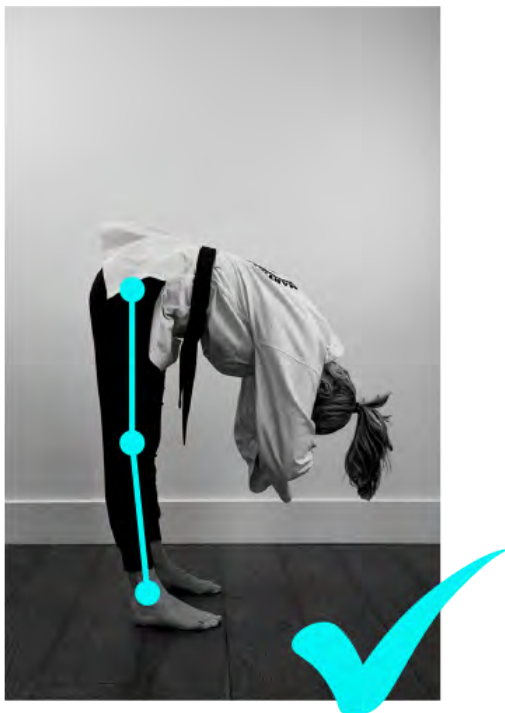


Spinal Roll Down

- Start with your feet hip width apart, with 60% of your body weight in the balls of your feet.
- Roll down your spine evenly, bone by bone.
- Reverse the movement until you are upright again.
- Repeat 5 times.

Key Teaching Points

- Maintain the upright position of your pelvis until your spine is fully flexed, don't move it too soon.
- Focus on moving each vertebra segmentally.
- Avoid shifting your weight backwards into your heels.



Cossack Squat

- Stand with your feet wide apart in a comfortable stance, toes forwards or turned out slightly.
- Shift your weight to one side and lower your hips to squat deeply, keeping your other leg straight and your heels on the floor.
- Press into the floor with your bent leg to bring yourself up again and switch to the other side.
- Repeat 5 times on each side.

Key Teaching Points

- Keep your torso upright.
- You can allow your straight leg to rotate so your toes point upwards, as long as you keep your heel on the floor.

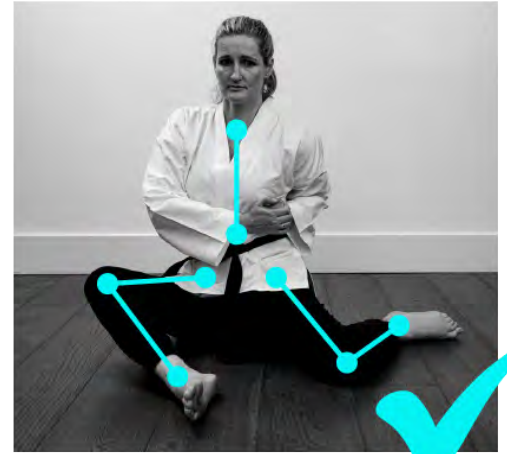


Shin Box

- Sit on the floor with your feet flat on the floor and wide apart.
- Keeping your knees bent, let them drop to one side and take them as close to the floor as you can.
- Rotate your legs to the other side, without using your arms for support.
- Repeat 5 times on each side.

Key Teaching Points

- Keep your torso as upright as possible.



Downward Dog (walking)

- Start kneeling on all fours, with your hands under your shoulders and your knees under your hips.
- Lift your hips up towards the ceiling until your arms are in line with your torso.
- Lower one heel toward the floor, keeping the other knee bent.
- Alternate with the other side and repeat 10 times on each side.

Key Teaching Points

- Keep an even pressure across the palm of both hands.
- Avoid hunching your shoulders, maintain space around your neck.



6. Side Planks



There are two variations, the side plank with inner thigh raise and the Copenhagen Plank.

Both exercises strengthen the inner thigh muscles, lateral core muscles and shoulders. This is important in preventing groin injuries and to improve control, balance and optimal placement of the lower limb joints during MASS.

Once students can perform the side plank with inner thigh raise easily and with excellent form, they can progress to partner training the Copenhagen Plank.

Key Teaching Points

- Focus on keeping your shoulder blade in contact with your ribcage throughout.
- Lower slowly with control.

Side Plank with Inner Thigh Raise

- Start in a side plank position with your arm straight and your hand underneath your shoulder. Your lower leg should be bent and resting on the floor.
- Push the floor down with your arm and squeeze your inner thigh muscles to lift your lower leg.
- Lower and repeat 10 times on each side.

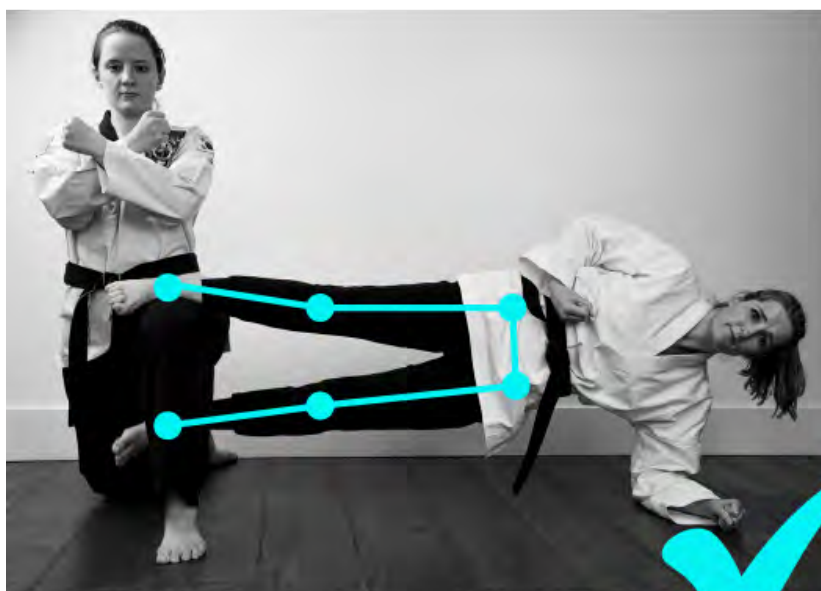
Copenhagen Plank

- Work with a partner who is kneeling on one knee.
- Lie on your side with your elbow on the floor directly under your shoulder and put your top shin on your partner's front thigh, keeping your knee straight.
- Using your top leg to press down into your partner's leg, lift yourself up to form a straight line with your body.
- Lift and lower your underneath leg using your inner thigh muscles, 3 – 5 times on each side.

Side Plank with Inner Thigh Raise



Copenhagen Plank



7. Plank with Scapular Press-up



The plank builds core strength, which stabilises the torso during all movements and allows for the transfer of power to and from the arms and legs.

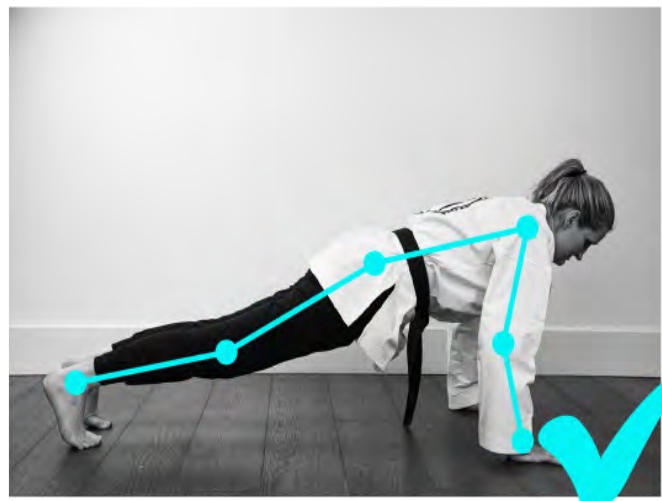
Adding scapular press-ups strengthens the muscles around the shoulder blades to assist a powerful striking movement, while teaching effective control at the elbow joint.

Instructions

- Start on all fours with your hands under your shoulders.
- Step back with one leg with your toes tucked under.
- Step back with the other, until your body is in a straight line.
- Draw your shoulder blades together and then press the floor down with your hands, to feel your ribcage rise up.
- Repeat 5 – 10 times.

Key Teaching Points

- This exercise can be performed at a lower level on hands and knees first ($\frac{3}{4}$ plank position) to practice the scapular press-up technique, before performing in full plank.
- Your weight should be evenly distributed across the whole palm of your hand.
- Elbows should be straight but not bent backwards (hyperextended).
- Avoid arching your lower back or lifting your hips.



8. Wide Squat with Forefoot Control



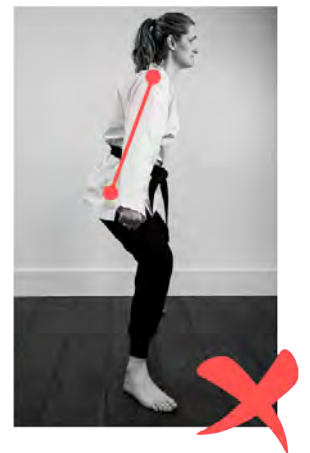
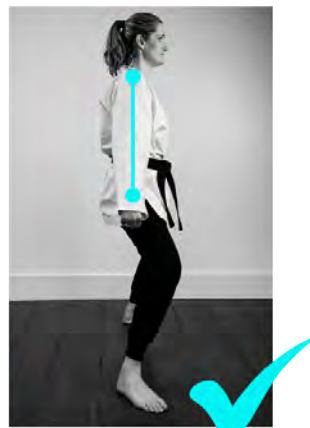
This exercise challenges the pelvic floor to build strength and control, as well as increased strength and coordinated control of the quadriceps and hamstrings. Lifting one heel at a time (or both heels together) challenges balance and improves movement control.

Instructions

- Stand with your feet beyond hip width apart and with your feet slightly turned out.
- Keeping your back straight, lower into a squat sending your knees wide over your toes.
- Raise and repeat 10 times.
- Then raise one heel and squat 10 times.
- Repeat with the other heel lifted.

Key Teaching Points

- At the bottom of the squat, you should be able to see your big toe on the inside of your knee. If not, turn your knees out a bit more.
- Keep your pelvis upright and imagine you are sliding your back up and down a wall.



POTENTIATE Exercises



10 minutes

This part of the programme includes exercises to stimulate fast responses, and prepares the student for higher impact and more explosive forces. It stimulates an efficient and quick response to extrinsic factors such as an uneven floor surface, contact from a partner, or landing a kick.

9. Single Leg Deadlift



Single leg deadlifts introduce sports specific movement patterns, build core control and balance, and pinpoint any muscle imbalances by working one side of the body at a time. Students should start with the assisted deadlift and progress through the harder variations once they can perform the previous one easily and with excellent form.

Key Teaching Points

- Keep your spine straight throughout this movement.

Assisted Deadlift

- Stand with your body weight on one leg.
- Place your other leg behind you for balance, using only your tip toe.
- Lean forwards, bending at the hip joint (you should feel a gentle stretch in your hamstrings).
- Rotate your pelvis and torso upright again to rise.



Unassisted Deadlift

- Stand with your body weight on one leg.
- Place your other leg behind you for balance, using only your tip toe.
- Lean forwards, bending at the hip joint and lifting your back leg (aiming for a straight line from your body to your leg).
- Slowly lower your leg and rotate your pelvis and torso upright again.



With Hip Rotation

- Stand with your body weight on one leg.
- Place your other leg behind you for balance, using only your tip toe.
- Lean forwards, bending at the hip joint and lifting your back leg.
- Hold this position and turn your pelvis and chest up away from your support leg.
- Turn back again and slowly lower your leg and rotate your pelvis and torso upright.



With Mini Squat

- Stand with your body weight on one leg.
- Place your other leg behind you for balance, using only your tip toe.
- Lean forwards, bending at the hip joint and lifting your back leg.
- Hold this position and turn your pelvis and chest up away from your support leg.
- Bend and straighten your knee 5 times.
- Turn back again, slowly lower your leg and rotate your pelvis and torso upright.



10. Star Excursion with Pivot Shift



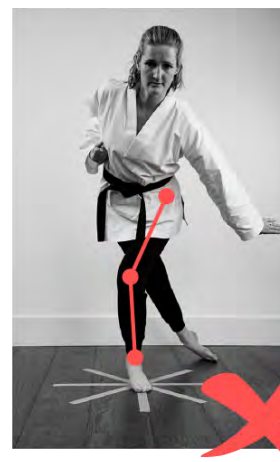
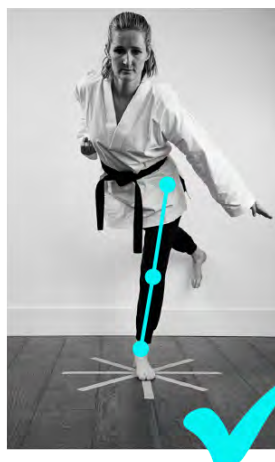
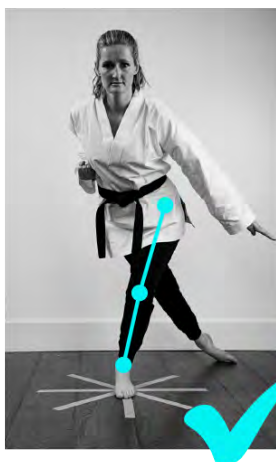
This exercise teaches ankle stability and improves trunk control and alignment of the knee joint. It can be performed with the reaching leg in contact with the floor, or progressed so that the reaching leg is off the floor for more experienced students.

Instructions

- Stand on one leg and imagine a star pattern on the floor.
- Reach with your free foot along one of the arms of the star as far as you can, while maintaining your balance.
- Come back to the centre, then lift your heel and pivot 90 degrees on the ball of your foot.
- Reach your free foot along one of the other arms as far as you can again.
- Return to the centre and pivot again.
- Repeat until you have reached in all directions.

Key Teaching Points

- Focus on maintaining alignment of your knee over your ankle joint throughout.



11. Jumps



This exercise improves your power for jumping, and knee control for both take-off and landing.

Start with 3 – 5 lower jumps initially, then build up the power and height of each attempt. Turning in the air through 90 – 360 degrees can be added, as long as good HKA alignment is maintained on take-off and landing.

Single leg hopping can be added as a progression for more experienced students.

Instructions

- Stand with your feet hip width apart.
- Bend your hips, knees and ankles and lean forwards slightly.
- Jump as high as you can.
- Land softly on the balls of your feet.

Key Teaching Points

- Focus on the alignment of your knees on both take-off and landing, don't let them buckle inwards.
- Bend your knees to cushion the landing.



12. Lunge with Contact



This exercise improves balance, strength and coordination, and a coordinated response to physical contact with a partner.

Instructions

- Start in a split lunge position.
- Maintain your position and balance while a partner makes light contact.

Key Teaching Points

- Focus on maintaining alignment of your front knee over your ankle joint throughout.
- Keep your torso upright.
- Keep your pelvis level and facing forwards.





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