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Contents

Development of sports therapy research

Welcome to the summer edition of the Journal of Sport Therapy 2010.

We celebrate an increase in the circulation of the Journal of Sport Therapy both locally and internationally, through submissions of manuscripts from international readers and editorial members. This is an excellent development as it demonstrates how sports musculoskeletal researchers are keen to share findings with the global community. The breadth of the Journal of Sport Therapy has significantly increased, evidenced by an increase in manuscripts being submitted from both new and established researchers. With the addition of an ISSN, coupled with swift publication of manuscripts, the popularity of the Journal of Sports Therapy would seem a feasible option as a publication outlet for research related to musculoskeletal therapy and physical activity.

However, there is a need to further develop the research output of the Sports Therapy industry. To this we have identified the need for an improved communication, co-operation and transparency by all stakeholders involved in the sports therapy industry, namely, member associations, educational institutions, practitioners, and researchers. The need for an appropriate forum to disseminate and communicate developments within the industry is key to the further development of the Journal of Sports Therapy. Open and free communication is crucial for the progress of the Journal of Sports Therapy as a unified entity. It is the aim of the editors to promote the Journal of Sports Therapy as an outlet for research pertinent to the care of active individuals, as mentioned in previous editorials; the multidisciplinary approach to health care seems to be an emerging trend in health care provision.

The editors invite communication from new and established practitioners and researchers who might be interested in forging collaborative partnerships which reflect the philosophy of the Journal of Sports Therapy. Projects which we would consider important to the industry include conducting multi-site research activities in common themed areas. Establishing a research hub may be of interest to researchers who might consider undertaking some research but may lack the necessary facilities, and expertise. In the first instance, we invite you to contact us to discuss your thoughts. This is a potentially powerful way to enhance knowledge and practice which can be widely disseminated amongst the sports therapy community. Given today's research and clinical environment, collaboration is vital.

Editors
Robert Di Leva and Ian Lahart

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Original Research

The design of a judo-specific strength and conditioning programme

Part II. Judo-specific Strength and Conditioning Methods

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KEY WORDS

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Physiology.
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ABSTRACT

Strength and conditioning programme design for any sport requires a multifaceted approach. Sports-specific skill-based high-intensity interval training, Olympic weightlifting exercises, circuit training, plyometrics, and complex training are strength and conditioning methods that can all be tailored to meet the specific technical and physiological demands of actual competition. The following article provides a guide for those involved in the design of strength and conditioning programmes, for Judo in particular, on how to apply the information gained from a needs analysis (see Robertson & Lahart, 2010, part I) and select and modify appropriate training methods to meet the specific demands of Judo.

Introduction

Optimal sporting performance requires the use of optimal training methods. To be considered optimal, training methods must be sports-specific, that is to say they should stress the physiological systems associated with performance in a specific sport. Specific training should consist of three components, skill specificity, muscle-group specificity, and energy system specificity. To achieve specificity similarities should exist between the training conditions and those required in the field during competition. Training methods that reflect the intensity and duration of exercise bouts in competition should be incorporated into athlete's programmes. The aim of part II of this article is to show how the need analysis (see Robertson & Lahart, 2010, part I) information can be applied to the selection of judo-specific strength and conditioning methods and ultimately the design of a judo-specific training programme.

High-intensity Interval Training (HIT)

Judo competition involves repetitive bouts of high-intensity exercise. Successful performance is dependent on not only maintaining these bouts over the full duration of a match, but also on the ability to recover from each exercise bout (Maughan & Gleeson, 2004). To enhance the performance of and recovery from repetitive high-intensity exercise, high-intensity interval training (HIT) is recommended. HIT may be defined as repeated bouts of short-to-moderate duration exercise (5 s - 5 min) performed at intensities above VO2max. Recovery can be either active or passive, but of a duration where sufficient recovery is not achievable. The rationale for HIT is to provide adaptation by continually stressing sports-specific physiological components above and beyond the level required during actual competition (Shave & Franco, 2006).

HIT is associated with a number of desirable biochemical adaptations and improvements in high-intensity exercise performance. HIT has been shown to enhance the capacity of the ATP-PC system through an increase in intramuscular ATP, phosphocreatine, and free creatine stores, and raised concentrations and activity of specific enzymes, including creatine kinase and myokinase (van Someren, 2006). Furthermore, HIT has been shown to elicit adaptations associated with an improved capacity of the lactate system, including increases in intracellular and extracellular lactic acid buffering capacity, enhanced enzymatic activities related to glycolysis (e.g. phosphofructokinase and lactate dehydrogenase), and raised concentrations of glycogen (Linossier et al., 1997; Dawson et al., 1998; MacDougall et al., 1998; Parra et al., 2000).

In addition to this, HIT can develop judoka ability to tolerate a greater accumulation of lactic acid. This tolerance may be crucial near the end of a contest, for example, Sterkowicz and Franchini (2000) observed in judo that the majority of fractional points are scored in the first 2 minutes of a bout at the elite level, this lack of points may be due to fatigue, and the judoka who retains the ability to attack in the final minutes may hold the advantage over their opponent as they will be able to continue to accumulate points.

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Moreover, HIT may provide a more time efficient method for improving endurance performance comparable to traditional endurance training (Krustrup, Hellsten, and Bangsbo, 2004; Gibala et al., 2006). HIT training comprising of 4 to 7 bouts of 30 s high-intensity cycling exercise separated by 4 minute recovery, performed six times over 2 weeks, has been shown to significantly improve exercise tolerance during tasks that rely on aerobic metabolism. These HIT sessions doubled the length of time that submaximal exercise could be maintained from 26 to 51 minutes during exercise at 80% of VO2max (Burgomaster et al., 2005), and also improved the ability to complete a fixed amount of work (e.g. 10% reduction in time to complete a simulated 30-km cycling time trial) (Gibala, 2007). Findings of this nature demonstrate the effectiveness of HIT to enhance both anaerobic and aerobic capacity, and question the use of traditional non-specific training methods such as long distance running to increase judoka aerobic capacity.

As mentioned previously, successful judoka tend to possess lower body fat levels. In addition to this, most judoka compete at a weight classification lower than their natural body weight. To avoid the use of performance inhibiting and dehydrating weight loss methods, such as calorie restriction, saunas, and the wearing of wet-suits during exercise, in the final 3-days prior to competition, trainers must identify a time scale for safe weight reduction (Smith et al., 2000). HIT has been shown to result in a greater reduction in sum of skinfold measures compared to continuous endurance training (Tremblay, Simoneau and Bouchard 1994; Stepto et al., 1999). Using interval training intensities of 120% VO2max, Overend et al. (1992) demonstrated that while HIT over 6 weeks resulted in similar increases in VO2max as endurance training at 80% VO2max, HIT resulted in a significant decrease in sum of skinfold values from a pre-test level of 39.6 mm to a post-test level of 36.5 mm. Therefore, HIT training provides an effective method of reducing athletes' body fat levels, and in turn controlling body weight.

Sample HIT Sessions for Judo

The adaptations that HIT elicits are specific to the bout intensity and the work-to-rest ratio employed (Harmer et al., 2000). Brief, high-intensity (< 10 s) bouts with longer recovery periods are proposed to induce an adaptive response in phosphocreatine metabolism, while longer higher intensity intervals (30 - 60 s) are used to produce a greater adaptive response in lactate metabolism (Cadefau et al., 1990; Harmer et al., 2000; Cramer, 2008). Insufficient recovery periods between repeated HIT have been shown to inhibit phosphocreatine hydrolysis and anaerobic glycolysis, and result in an increased contribution from aerobic metabolism (Parolin et al., 1999). Thus, to impose adaptations upon specific energy systems the work-to-rest ratio employed must be carefully considered, whilst keeping in mind the specific demands of the sport.

For judo, work-to-rest ratios of 1.5 and 3: 1 would accurately reflect those observed in actual competition, for example, judoka can perform high-intensity exercise lasting between 10 to 30 s, separated by 10 s rest periods, performed over a duration of 5-min (Franchini et al., 2003). To focus more on developing specifically the capacity of the ATP-PC system high-intensity interval durations of 5 to 10 s with work-to-rest period ratios of 1: 12 to 1: 20 are required, while for adaptations to the lactate system capacity high-intensity interval durations of 15 to 60 s with work-to-rest ratios of 1:3 to 1:5 are recommended (Cramer, 2008).

As well as being energy system specific, optimal sports training should also be skill-specific and muscle group-specific. The importance of technique in judo means that time spent engaged in non-specific training modalities may be counterproductive as technique may suffer. With this in mind, skill-based HIT sessions utilising sparring (randori) should be incorporated for more sport specific conditioning manipulated to reflect the work-to-rest ratios observed actual competition and effectively develop judo specific anaerobic capacity (Ratamess, 1998; Amtmann & Cotton, 2005).

Short duration, high-intensity sparring intervals are vital to simulate the intensity and conditions of actual competition. In judo, the rest periods observed during competition are not sufficient to allow the judoka to recover, as such rest intervals for HIT should not exceed 60 s (Amtmann & Cotton, 2005; Bonitch et al., 2005). Therefore, randori intervals of 45 to 60 s with 30 s rest, repeated 5 to 6 times, would be ample to develop the judo-specific anaerobic ability of judoka. In addition to developing anaerobic and aerobic capacity, sparring can be used to increase the choice reaction time of athletes, i.e. sensory skills specific to an athlete's sport, described as the shortest interval needed to respond to a stimulus that is presented as an alternative to a number of other stimuli (Morris & Trimble, 1989; Schmidt, 1990).

However, there are some important limitations of this type of reaction time training that should be considered. For example, because training partners become familiar with one another, they can easily predict and anticipate each other's movement, and while this can be effective in training situations, in competition where the opponents are most often unknown, the reaction time will be longer (Roosen & Pain, 2006). Therefore, there is a need for judoka to spar with a large variety of opponents, which may involve travelling to other clubs to prevent this 'anticipation contaminated' choice reaction time training.

Strength and Power Training for Judo

Judoka require the ability to develop high forces in order to throw opponents despite their defensive resistance, and to perform a wider range of throws, so that they can incorporate more power-based throws into their technical repertoire. In addition to developing throwing specific strength, judoka require the development of elbow flexion/extension strength (Kubo et al., 2006) and grip strength (Carvalho et al., 2007) in order to obtain an advantageous position, and neck strength to minimise the risk of cervical spine injury. While, isometric strength is not as important during standing fighting, it has an important role during ground fighting (Sterkowicz & Franchini, 2000; Franchini et al., 2007).

Resistance training, through manipulation of variables such as training modality, frequency, volume, intensity, velocity and rest intervals, can elicit favourable neuromuscular adaptations (Stone et al., 2000). Of particular benefit to the judoka is the potential to increase strength and power. However, due to judoka competing in weight categories, prudent use of resistance training is required as increases in mass can result from the use of certain protocols.

Strength gains are typically achieved with loads in excess of 80% of 1RM in order to achieve an intensity that will recruit the higher threshold fibres (Hoffman et al., 2004; Zatsiorsky & Kraemer, 2006). Rest intervals must be long enough (> 2mins) to ensure that this intensity can be maintained over several sets (Willardson, 2006). Adaptations to training of this nature are primarily neural as the fibres do not undergo enough mechanical work to provoke sufficient protein degradation to induce muscular hypertrophy due to the lower volumes of training (Zatsiorsky & Kraemer, 2006). This may be of benefit to the judoka as greater forces can be exerted as a result of strength training without the gaining of mass, which allows the athlete to remain in their particular weight category.

Whilst increasing the amount of force a judoka can exert is important, training the athlete to be able to exert force rapidly is equally, if not more important. Working with loads greater than 80% 1RM when utilising traditional power-lifting exercises (e.g. squat, deadlift) will not improve rate of force development (RFD) as the velocity of the movement will not necessarily be sufficient to develop power (McBride et al., 1999). Therefore, when the aim is to increase RFD using lighter loads (30-80% 1RM) for traditional power-lifting type exercises, and the use of explosive lifting techniques such as the Olympic lifts (clean and jerk, snatch) and their variations (e.g., power clean, high pull) is recommended as higher movement velocities can be achieved (Baechle, Earle, and Wathen, 2000). Similar to strength training protocols the volume for explosive lifting is low and the rest periods between sets must be of sufficient duration to ensure recovery and therefore maintenance of intensity (Willardson, 2006). This is of particular importance with lifts of this nature as neurally they are very demanding (Zatsiorsky & Kraemer, 2006).

Improvements in throwing technique and increases in the force developed whilst throwing have been achieved utilising a validated judo specific strength-training machine. In addition, were also noted (Blais & Trilles, 2006; Blais, Trilles & Lacouture, 2007b). In the absence of a judo-specific machine, maximal strength weight training techniques, plyometrics, and complex training methods utilising an opponent have all been shown to improve throwing speed (Villani & Vincenzo, 2002) and the number of throws achieved in a judo specific throwing test (Vecchio, Miarka, and Franchini, 2007). Villani and Vincenzo (2002) utilised a contrast throwing technique known as butsukari where a third judoka provides additional resistance to a set of throws followed by nagekomi (throw without the additional resistance). This method of 3 sets of 2 x 3 butsukari followed by a single nagekomi with complete recovery between sets significantly improved throwing speed compared to a group utilising nagekomi and lifting exercises.

Grip strength can be developed by employing supplemental resistance exercises (e.g. towel pull-ups) in addition to multi-joint, judo-specific strength training (Amtmann & Cotton, 2005; Kraemer, Vescovi, and Dixon, 2004; Szymanski et al., 2004). Elbow flexion/extension strength endurance can be developed using loads of up to 80% of 1RM with multiple sets separated by short rest intervals (Zatsiorsky & Kraemer, 2006). The need for specific neck musculature training in addition to other strength training methods has been recommended for judoka (Conley et al., 1997). Amtmann and Cotton (2005) proposed 3 sets of 10 to 20 repetitions in a circuit format would be effective for developing neck musculature. All cervical spine movements (flexion, extension, lateral flexion) must undergo the same volume of training unless there is a weak movement that requires a greater volume to bring it to the same level as the other movements (Ylinen et al., 2003).

Judo Circuit Training

The requirement of judoka to maintain force output for the duration of a bout necessitates the development of muscular endurance (Murlasits, 2004). A method commonly used by judoka to enhance muscular endurance is circuit training. An effectively designed circuit may increase capillarisation, thereby improving the potential to clear metabolic by-products which in turn can enhance the ability of the muscle to deal with metabolic acidosis during intense exercise (Tan, 1999). In addition to this, circuits can be designed to safely create a metabolic state similar to that elicited during actual sports competition. This provides trainers with an effective alternative specific conditioning method that reduces the need for continuous sparring, which exposes judoka to an increased risk of injury (Amtmann & Berry, 2003).

Circuit training sessions can include resistance training exercises only, or a combination of resistance training and conditioning exercises (e.g. sprinting, skipping, shadow striking, etc.). Both dynamic bodyweight exercises, such as pull-ups/chin-ups, dips, and press-ups, and isometric bodyweight exercises, including squat holds and planks, in addition to partner assisted exercises such as lifting or carrying a partner of similar body mass, can be used in circuit training to effectively develop relative strength (Murlasits, 2004). Circuits can also include explosive resisted sprints to develop leg power and resisted throwing actions to develop throwing power and rate of force development.

Circuit training sessions can be developed in accordance with the specific demands of the sport by matching the work-to-rest ratios of the bouts. A judo specific circuit could consist of a 5 min circuit consisting of 10 exercises performed for 20 s each, with 10 s given for changeovers, followed by a 10 min rest, repeated two to three times (see table below for sample exercises).

Table 1. Sample Circuit Training Session

1.	Sandbag clean and shoulder
2.	Static squat
3.	Woodchop
4.	Neck Bridge
5.	Tractor tyre flip
6.	Mountain climbers
7.	Inverted Body Press
8.	Rope climb
9.	Pull-ups (with hold*)
10.	2-point plank

**isometric hold ½ way on eccentric phase for 2 s in each rep*

Plyometric Training for Judo

Any increase in the amount of force that a judoka can develop in the short period of time available for a throw to be executed, provides them with a greater chance to overcome the defensive force exerted by their opponent. Due to the short duration of throws, maximal power typically cannot be generated; therefore, increases in power are largely dependent on the rate of muscular force development (Siff, 2000). Plyometric training is a method of choice when aiming to enhance both lower and upper body muscular power (Markovic, 2007). Plyometrics seeks to improve the rate of force development and power output arising from the stretch-shortening cycle (SSC) (Boreham, 2006). The SSC combines mechanical and neurophysiological components, and involves a rapid eccentric muscle action to stimulate the stretch reflex and storage of elastic energy, which increases the force produced during subsequent concentric (Potach & Chu, 2000). Lower body plyometric exercises are primarily based on jumping activities, such as depth jumps, standing jumps, hopping, etc., while upper body plyometric exercises typically include a variety of medicine ball throws and clap push-ups.

There are numerous studies illustrating the effectiveness of plyometric training in improving muscular power (Toumi et al., 2004; Schulte-Edelmann et al., 2005; Markovic, 2007). However, although there appears to be a large evidence base justifying the use of plyometric training for athletes, it is not recommended for inexperienced or poorly conditioned individuals, and should not be performed over prolonged periods due to the risk of injury and the rapid onset of fatigue (Potach & Chu, 2000). Furthermore, due to the number of high eccentric contractions performed during plyometric training delayed onset muscle soreness (DOMS) is invariably experienced, which can impact on subsequent sessions (Boreham, 2006). Highlighting the effect of plyometric training on subsequent sessions, Twist et al. (2008) recently demonstrated a latent impairment of balance performance following a bout of plyometric exercise, which the authors suggested has implications for both skill-based activities performed post plyometric training and for increased injury risk following high-intensity plyometric training. Aquatic plyometric training may be of particular interest to athletes and trainers as it may potentially reduce the risk of injury and the amount of post bout muscle soreness associated with plyometric training, whilst producing power gains equivalent to those seen after land-based plyometric training (Robinson et al. 2004; Stem and Jacobsen, 2007)

The following plyometric programme design recommendations have been adapted from Ebben (2007):

Plyometric Training Recommendations

- Athletes should perform only 2-3 plyometric sessions per week.
- Plyometric training should be performed in a non-fatigued state, therefore, it should not be performed after resistance training or sports conditioning sessions.

- Plyometric sets should not exceed 10 reps, and should be performed across a variety of rep ranges, such as sets of 1, 3, 5, or 10 reps, so as to develop explosiveness as well as power endurance.

- Generally, rest intervals between sets should be 5 to 10 times the duration of the set of plyometric exercises performed. For example, if a set of vertical jumps lasts 6 s, the rest interval should be 30 to 60 s duration.

- For beginners a volume of 80 to 100 foot contacts are recommended, while 100 to 120 and 120 to 140 foot contacts are recommended for intermediates and advanced level athletes, respectively.

- When possible perform in knee-deep water (Robinson et al. 2004; Stem and Jacobsen, 2007).

In addition to foot contacts, the intensity of the plyometric exercise should be considered when deciding training volume. Plyometric intensity is based on the muscle activation, connective tissue and joint stress associated with various exercises. Assuming all exercises are performed maximally, a single leg exercise is more intense than its two-legged equivalent. Typically, the higher the jump the greater the ground reaction force (GRF), therefore, the greater stress caused. Jumps with added resistance (e.g. using dumbbells) are classed as moderate intensity due to the limiting effect that added resistance has on the jump height, and in turn GRF. Conversely, jumps performed while reaching the arms overhead result in higher jump heights, and therefore, greater intensity (Ebben, 2007).

Table 2. Sample Plyometric Training Session

1. Squat Jumps	2 x 8
2. Split-squat jumps	2 x 8
3. Clap press-ups	2 x 6
4. Plyometric sit-up with Medicine ball	2 x 6
5. Box jump	2 x 5
6. 12 inch depth jump	5 x 3
Volume	**81 foot contacts**

Complex Training for Judo

Power can be developed with the use of heavy loads (80-90% of 1RM), plyometric exercises using body weight, and the use of explosive movements where the athlete moves 30-50% of 1RM as fast as possible (Docherty, Robbins, and Hodgson, 2004). Recently the use of complex training techniques has been advocated as an effective method of improving power by practioners and researchers, including most notably Verkoshanski. Complex Training involves the completion of a strength training exercise using a heavy load (1-5RM) followed after a relatively short period by the execution of a biomechanically similar plyometric exercise (Ebben & Watts, 1998). For example, 5 repetitions of a bench press with a 5RM load followed by 8 clap press-ups.

Advocates of complex training purport that the explosive capability of muscle is enhanced after it has just been subjected to maximal or near maximal contractions, which in turn creates optimal training conditions for subsequent plyometric exercise (Docherty, Robbins, and Hodgson, 2004). This effect of prior maximal or near maximal contractions appears to last up to 8-10 min, and is referred to a 'post-activation potentiation' (PAP) (Docherty, & Hodgson, 2007; Sale, 2002; Smilios et al., 2005). This PAP effect has been acknowledged as providing an opportunity for enhancing force and power production and exceeding performance achieve without prior loading (Deutsch & Lloyd, 2008). Ebben and Watts (1998) suggest that the most powerful affect of complex training may be neuromuscular, and in particular an increased motorneuron excitability and reflex potentiation, in addition to a possible increase in the motor units recruited, leading to an enhanced training state.

Complex training should only be used after functional strength is developed, basic jump training is performed, and/or after several weeks of sprint and resistance training (Chu, 1992; Hedrick & Anderson, 1996). Sessions should be designed around the following recommendations of Ebben and Watts (1998):

- The volume of complex training should be low enough to guard against undue fatigue so the athlete can focus on quality.

- Sets of 2-5 of each pair with 2-8 reps of the resistance exercise and 5-15 reps of the plyometric should be performed, with 0-5 min rest between exercises and 2-10 min rest between pairs.

- 1-3 complex training sessions recommended per week with 48-96 hours recovery between sessions.

Blais and Trilles (2006) found considerable benefits for judoka by performing complex training methods in a 10-week training programme consisting of 2 sessions per week, with 5 sets of 10 repetitions on a judo-specific machine alternated every set with 10 repetitions of a partner throwing exercise. The utilisation of such a machine allows the maintenance, or even improvement, of technique whilst increasing the force devel-

Table 3. Sample Complex Training Session

Exercises	Sets	Reps	Load	Tempo	Rest
1A. Clean and Press 1B. Vertical Jump	3	5 10	5RM -	Explosive Explosive	30 s sets 4 min pairs
2A. Dumbbell Chest Press 2B. Medicine Ball (MB) Drop	3	5 10	5RM ≥10 kg	Slow Explosive	30 s sets 4 min pairs
3A. Back Squat 3B. Depth Jump	3	5 10	5RM -	Slow Explosive	30 s sets 4 min pairs

oped at appropriate velocities whilst throwing, and minimising the amount of throws an opponent has to be subjected to if a similar protocol was to be followed using an opponent as resistance.

In addition to this, performing near maximal squats (95% 1RM) or depth jumps (plyometrics) prior to throwing also improves throwing speed as more throws can be carried out in a given period of time after using either of these techniques (Vecchio, Miarka, and Franchini, 2007). Both the depth jumps and maximal squats utilise lower body musculature and it is the lower limbs that provide the majority of the force when throwing (Blais, Trilles, and Lacouture, 2007a), therefore this musculature must be targeted when developing strength and power if throwing performance is to be improved.

Table 4. Judo Specific Complex Training Pairs

Authors	Modality	Sets	Reps
Blais & Trilles (2006)	Judo specific strength machine	5	10 x strength machine/10 x partner throws
Villani & Vincenzo (2002)	Opponent(s) as resistance	3	(3 x butsukari/1 x nagekomi)

Conclusion

It is clear from the first part of this article that judo competition places a unique metabolic demand on the competitors, and in turn requires training strategies that are specific to these demands. Effective strength and conditioning programme design for judo is multi-faceted and must look to implement training methods that sufficiently stress the anaerobic and aerobic energy systems, while developing strength and power components in a manner specific to how they are utilised in competition. Due to the technical nature of each of judo, it is recommended that judoka integrate specific skill-based conditioning methods, such as sparring-based HIT sessions, into their training. It is advised that in judoka where maintenance of a particular weight category is important, power and strength training that targets improvements in relative strength should be preferred to traditional high-volume bodybuilding resistance training methods. The methods recommended in this article include Olympic weightlifting exercises, circuit training using predominantly bodyweight exercises, plyometric training, and complex training. In closing, it is important that strength and conditioning coaches employ evidence-based practice when designing training programmes for judoka, and utilise training methods that are as sport-specific as possible.

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Original Research

Effect of ankle taping and bracing on the performance of professional male soccer players

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KEY WORDS

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Agility, Sprinting
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ABSTRACT

The ankle is the most common site of injury in soccer. While bracing and taping have been reported to reduce injury risk to the ankle-foot complex, their effect on soccer performance remains equivocal. Following institutional ethics approval, 16 professional male academy players from the English Football League Division 1 (Age mean = 17.19 ± .75 years, Height mean = 1.80 ± 0.05M, Mass mean = 75.55 ± 5.9kg) completed nine trials (three control, three braced, and three taped) in each of three soccer-specific performance tests: 15m Sprint, Arrow Agility Run, and Vertical Countermovement Jump. All tests were randomised to reduce any order effects, with 10 minutes recovery between conditions to reduce the effect of fatigue. All participants were free from injury to the lower extremities in the previous six months. Repeated measures ANOVA revealed no significant difference (P = 0.3) in agility performance in control (11.49 ± 0.7s) braced (11.51 ± 0.68s) or taped (11.57 ± 0.68s) conditions. Repeated measures ANOVA also revealed no significant difference (P = 0.24) in jumping performance in control (0.47 ± 0.04m) braced (0.47 ± 0.04m) or in taped (0.47 ± 0.04m) conditions. Repeated measures ANOVA revealed a significant difference (P = 0.008) in sprint performance in control (2.53 ± 0.19s) braced (2.56 ± 0.22s) and taped (2.60 ± 0.21s) conditions. A Pair wise comparison then indicated no significant difference (P = 0.83) between control and bracing and no significant difference (P = 0.62) between bracing and taping. A significant difference (P = 0.03) was found, however, between control and taping conditions. With previous studies indicating superior injury reduction with bracing over taping, the current study provides players, coaches and therapists with evidence supporting semi-rigid ankle brace use in soccer performance.

Introduction

Due to the physical nature of the game of soccer, injuries are common place (Woods *et al.*, 2003). Epidemiological studies and meta-analysis have reported that the most common site of injury in soccer is the ankle, accounting for between 19% and 24% of all soccer injuries, with up to 88% of these being reported as ligamentous strains (Fong *et al.*, 2007; Price *et al.*, 2004). Ankle injuries often occur as a result of a combination of inversion, plantar-flexion and internal rotation. Excessive motion in these directions can place strain on the lateral ligaments, and if the strain exceeds the tensile properties of the ligaments, then damage will occur (Eils *et al.*, 2002). Excessive inversion situations are mainly thought to be caused when an unloaded ankle is rotated into an excessive degree of inversion, before being loaded with the individual's body weight (Wright *et al.*, 2000). Acute ankle sprains occur during dynamic movement, particularly when rapidly changing directions. The lateral ligaments of the ankle-foot complex, which provide static support, are frequently torn, and the stability provided by the peroneal muscles is insufficient to limit forced inversion (Cordova *et al.*, 2002). Such situations may also be externally provoked in soccer where the landing surface is at an inversion angle to the foot at the point of ground contact; such as landing on another player's foot (Konradsen and Voigt, 2002). Cutting manoeuvres also place the ankle at particularly high risk as they induce peak mediolateral forces onto the ankle-foot complex of approximately 80% to 100% of an individual's body weight (Hawkey and Cloak, 2007; Hawkey and Lahart, 2007; McClay *et al.*, 1994; Orloff and Fujino, 2006).

Traditionally, prophylactic ankle taping has been the mainstay for prevention of ankle injuries (Garrick and Requa, 1973;

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Quigley *et al.*, 1946), and for over a century has been advocated as a means to protect the ankle ligaments from excessive strain (Gibney, 1895). Widespread belief in the effectiveness of ankle taping and the extremely high incidence of lateral ankle sprains among athletes has resulted in omnipresent use of the procedure within educational and professional athletic organisations. However, taping has long been criticised for loosening with physical activity, and it has been stated that it offers no useful support after 1 hour of exercise (Myburgh *et al.*, 1984). Loosening has been shown to result in a reduction of as much as 40% to 50% of the original support after only 10 to 30 minutes of exercise (Fumich *et al.*, 1981; Rarick *et al.*, 1962). Another criticism of the routine use of taping to stabilise the ankle is the total cost related to materials and the time and expertise necessary for suitable strapping application (Mickel *et al.*, 2006). For these reasons, a variety of ankle braces; laced, semi-rigid and rigid, have been developed. Such braces can be applied by the athlete, retightened during play (Greene and Hillman, 1990), and present a one-time cost to the athlete or athletic program (Rovere *et al.*, 1988).

Ankle taping and bracing have both been reported to reduce injury risk by preventing inversion through the restriction of excessive ankle range of motion (ROM) (Cordova *et al.*, 2002; Eils *et al.*, 2002; Simpson *et al.*, 1999), maintenance of the ankle's correct anatomical position on impact (Thacker *et al.*, 1999; Wright et al, 2000), via an increase in mechanical stability (Hume and Gerrard, 1998) and improved proprioception (Papadopoulos *et al.*, 2005). However, previous studies have shown that although the majority of braces and taping techniques have the potential to restrict injury, semi-rigid braces, which are usually made of neoprene with a thermoplastic insertion on both the medial and lateral sides, reduce inversion more significantly during both passive and rapidly induced inversion situations (Eils *et al.*, 2002).

Mickel et al (2006) conducted a prospective, randomised comparison of prophylactic ankle taping with semi-rigid ankle bracing for ankle sprain prevention in high school football players. They found no significant difference between injury reduction rates of the two conditions, although reported increased time and cost implications with the taping option. Rovere et al (1988) investigated over 50,000 injury exposures in collegiate soccer players and found significantly fewer were sustained when wearing braces as opposed to taping, while Surve *et al.* (1994) found that wearing an ankle brace lead to a reduction in the incidence of ankle sprains in soccer players over the course of a season. Laboratory-based studies have also shown that bracing significantly reduces peak lateral GRF significantly, with the application of an AircastTM ankle brace, during dynamic cutting manoeuvres (Hawkey and Cloak, 2007; Hawkey and Lahart, 2007).

An external ankle support's ability to reduce injury risk must also be matched by its capacity not to interfere with an individual's performance. It has been reported that the restriction in ROM, so crucial for injury reduction, is also responsible, possibly via a restriction in plantar-/dorsi- flexion, for the potential to limit performance (Simpson *et al.*, 1999). Paris (1992) compared the performances of 18 elite soccer players in selected tests of speed (45m sprint), agility (South East Missouri [SEMO]), balance (Nelson static and dynamic test) and vertical jumping (Sergeant Chalk Test) under conditions of bracing (McDavid A101, New Cross, Swede-O), non-elastic adhesive taping and control. Results showed no significant difference in speed or agility performance between conditions, but all bracing and taping conditions negatively affected jumping performance. However, despite many variables being well controlled in the study (such as recovery time, taping performed by a qualified Athletic Trainer, and randomisation of conditions), the measurement techniques employed are open to scrutiny. For example, performance in the speed and agility test was monitored using a stopwatch and jump performance involved the participant marking a wall with chalk. Also, Reilly et al (2005) suggest that a sprint test that exceeds 20m is not a valid test for soccer; recommending a distance of between 10-20m. These methods could have had a significant effect on the consistency and validity of measurement.

Hawkey, *et al.* (2007) used more sophisticated equipment, such as electronic timing gates and a digital jumping system and found, similarly to Paris (1992), that the application of a semi-rigid AircastTM ankle brace had no effect on speed and agility, but reduced vertical jump performance in basketball players. However, the reduction reported by Hawkey *et al.* (2007), albeit statistically significant ($P = 0.015$), was only 0.01m. In another study, Rosenbaum *et al.* (2005) reported no significant difference in a variety of soccer related tasks in 10 different ankle braces, although the AircastTM brace was reported to be the most popular due to its perceived ease of application and comfort. Other studies, conducted on a variety of sports and activities, have shown differing results.

While some studies report no reductions in performance while wearing taping (Greene and Hillman, 1990; Verbrugge, 1996) or a brace (Beriau *et al.*, 1994; Bocchinfuso *et al.*, 1994; Greene and Hillman, 1990; Gross *et al.*, 1994; Hawkey and Scattergood, 2007; Macpherson *et al.*, 1995; Pienkowski *et al.*, 1995; Verbrugge, 1996; Wiley and Nigg, 1996), other studies have shown that bracing (Burks *et al.*, 1991; Mackean *et al.*, 1997) and taping (Burks *et al.*, 1991; Mackean *et al.*, 1997) may adversely affect performance. The lack of consensus demonstrated in previous studies may be attributed to methodological differences, participant numbers, performance levels, bracing and taping techniques employed, sample variability, injury status and sporting activity. However, it would appear that the benefit in preventing injury outweighs the possibility of substantial but small impairments of performance.

Despite mounting evidence supporting superior injury reduction with brace use, Wilkerson (2002) reports that some sports medicine clinicians and athletes believe that taping provides superior benefits relating to comfort, perception of greater support, and less interference with normal ankle function. Further research is therefore needed to reduce the uncertainty regarding the use of external ankle taping and bracing, particularly in soccer where there is limited research investigating their effect on performance. Thus, the aim of the current study is to evaluate the effect of a semi-rigid ankle brace and non-elastic taping on soccer-specific performance.

Methods

Following institutional ethics approval, sixteen professional male soccer academy players (age mean = 17.19 + 0.75 years; height mean = 1.79 + 0.05m; mass mean = 75.55 + 5.9 kg), representing a team from the English Coca-Cola Division 1, completed a pre-test medical questionnaire and informed consent. Academy players were utilised due to their accessibility and because previous studies have reported that academy players from an English Premiership squad covered equivalent distances and performed movement patterns similar to their first team counterparts (Thacket and Batterham, 2004). All participants declared themselves free from injury, specifically with no injury to the ankle or lower limbs during the previous six months in accordance with Hawkey *et al.* (2007).

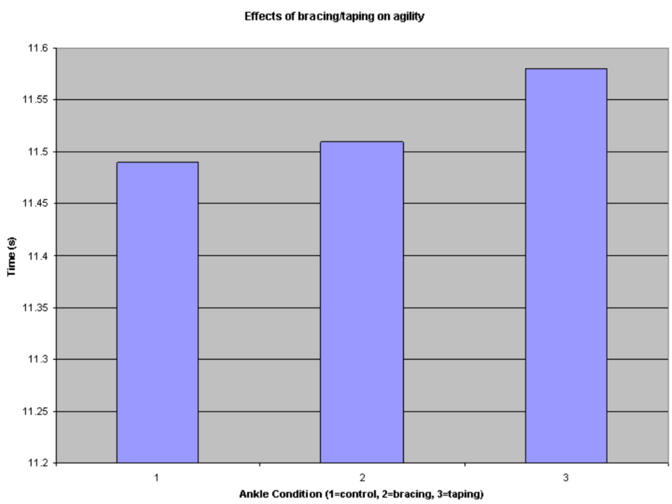
All participants performed nine trials (three control, three braced, and three taped) in three soccer-specific performance tests: 15m sprint, arrow agility, and vertical countermovement jump. The 15m sprint test was selected due to previous research reporting that soccer players sprinted all out on average for a distance of 10-15m (Bangsbo and Mohr, 2005; Bangsbo *et al.*, 2006). The Arrow Agility test was used in accordance with Smith and Galloway (2007) due to its reliability, and its ability to discriminate between agility and linear sprinting performance, and because soccer players have been shown to change direction up to 80 times in a single match (Bangsbo *et al.*, 1991). The vertical countermovement jump was used to assess whether the brace and tape conditions reduced jumping performance, as previous research has indicated a restriction in dorsi-/plantar-flexion and jumping performance following bracing and taping (Simpson *et al.*, 1999; Hawkey *et al.*, 2007) and because soccer players have been shown to perform up to 37 vertical movements during a game (Mohr *et al.*, 2003). Both the 15m sprint test and the arrow agility test were set out using a standard 30m tape measure and were timed using electronic timing gates (Brower Timing Systems, Utah, USA) to ensure accuracy. The vertical countermovement jump was performed on a digital jump mat (Just Jump, Probotic Inc, USA) in accordance with Hawkey *et al.* (2007).

The ankle brace used was a semi-rigid AircastTM AirsportTM (Aircast Inc, Summit, NJ), which has medial and lateral thermoplastic inserts lined with foam-filled air cell cushions, designed for prophylactic use and attached to the leg with three Velcro straps (Velcro USA, Inc., Manchester, NH). The brace was selected due to its popularity amongst sports performers (Sacco *et al.*, 2004) its apparent ease of application (Rosenbaum *et al.*, 2005) and its prevalence in previous studies investigating ankle injury reduction and performance testing (Sacco *et al.*, 2004; Sacco *et al.*, 2006; Hawkey and Cloak, 2007; Hawkey and Lahart, 2007; Hawkey *et al.*, 2007). The correct application of the ankle brace was explained and demonstrated to the participants and supervised by the research team. During the taping condition, a qualified physiotherapist performed each ankle taping using non-elastic adhesive tape; employing a previously reported ankle-taping procedure, which incorporated a Gibney closed basket-weave in combination with two Louisiana heel-locks and figure-8 wrapping patterns (Arnheim and Prentice, 1993; Mickel *et al.*, 2006; Wilkerson, 2002). A standard foam under-wrap material was also used for each application of tape to reduce possible skin irritation. The statistical package for social sciences (SPSS) was used for statistical calculations. Group means for agility, speed and jump performance in braced, taped and control conditions were analysed using a repeated measures ANOVA. Significance was accepted at $P = <0.05$.

Results

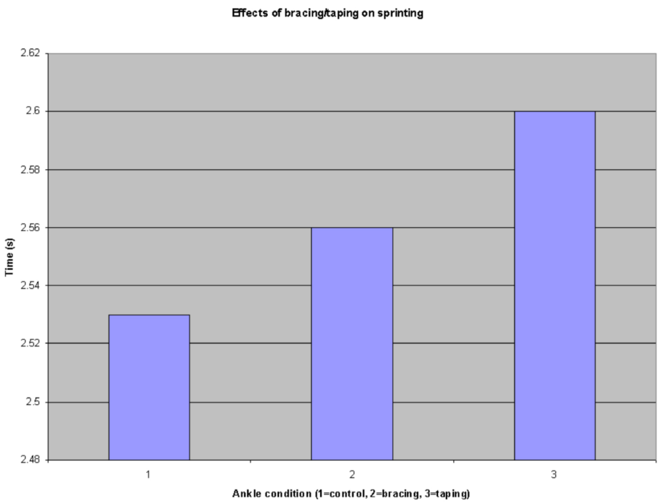
Repeated measures ANOVA revealed no significant difference ($P = 0.3$) in agility performance in control (11.49 ± 0.7s) braced (11.51 ± 0.68s) or taped (11.57 ± 0.68s) conditions (Figure 1).

Figure 1: Agility performance in control, braced or taped conditionsRepeated measures ANOVA also revealed no significant difference ($P = 0.24$) in jumping performance in



control (0.47 ± 0.04m) braced (0.47 ± 0.04m) or in taped (0.47 ± 0.04m) conditions (Figure 2).

Figure 2: Jumping performance in control, braced or taped conditions



Repeated measures ANOVA revealed a significant difference (P = 0.008) in sprint performance in control (2.53 ± 0.19s) braced (2.56 ± 0.22s) and taped (2.60 ± 0.21s) conditions (Figure 3).

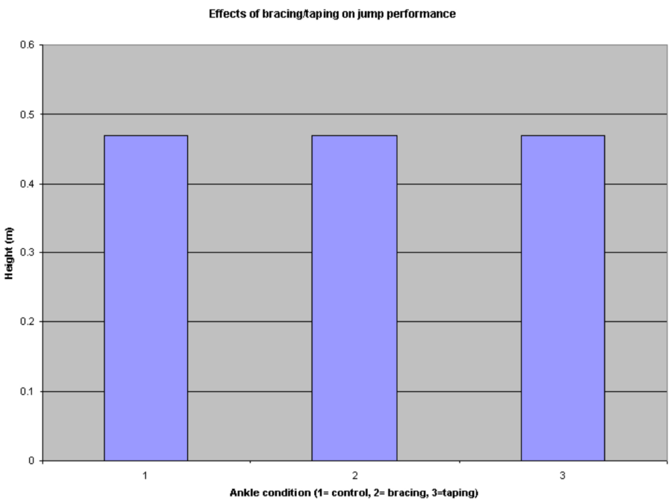


Figure 3: Sprint performance in control, braced or taped conditions

A Pair-wise comparison then indicated no significant difference (P = 0.83) between control and bracing conditions and no significant difference (P = 0.62) between bracing and taping conditions. A significant difference (P = 0.03) was found between the control and taping conditions.

Discussion

Traditionally, prophylactic ankle taping has been the mainstay for prevention of ankle injuries (Garrick and Requa, 1973; Quigley *et al.*, 1946), and has been omnipresent within educational and professional athletic organisations. However, taping has long been criticised for loosening with physical activity, the total cost related to materials and the time and expertise necessary for suitable strapping application (Mickel *et al.*, 2006). For these reasons, a variety of ankle braces have been developed. Both bracing and taping have been shown to reduce injury incidence in soccer players (Mickel *et al.*, 2006; Surve *et al.*, 2002), although semi-rigid bracing has been reported to the most effective in reducing injury risk (Eils *et al.*, 2002), while also being effective in decreasing force on the ankle-foot complex during cutting manoeuvres (Hawkey and Cloak, 2007; Hawkey and Lahart, 2007). However, despite mounting evidence supporting superior injury reduction with brace use, Wilkerson (2002) reports that some sports medicine clinicians and athletes still believe that taping provides superior benefits relating to comfort, perception of greater support, and less interference with normal ankle function.

There are also equivocal results from studies investigating the effects of bracing and taping on performance. While a number of studies report no performance reduction while wearing taping (Greene and Hillman, 1990; Verbrugge, 1996) or a brace (Beriau *et al.*, 1994; Hawkey and Scattergood, 2007; Wiley and Nigg, 1996), other studies have shown that both bracing and taping may adversely affect performance (Burks *et al.*, 1991; Mackean *et al.*, 1997). The purpose of the current study, therefore, was to determine the effects of brace and taping application on soccer-specific performance.

Results of the current study show that the application of a semi-rigid AircastTM AirsportTM ankle brace has no significant effect on agility, sprint or jump performance in professional male academy players. Results also show that ankle taping has no significant effect on agility and jumping performance, but does negatively affect sprinting performance. Paris (1992) reported no significant difference in speed or agility performance between conditions, but found reductions in jumping performance. However, the measurement techniques employed by Paris (1992) may not have been accurate or reliable. In addition, the braces used by Paris (1992) were older-style lace-up braces, which have been shown to be less effective than semi-rigid versions (Eils *et al.*, 2002). Hawkey *et al.* (2007) used more accurate methods of measurement and semi-rigid braces, and similarly to Paris (1992) found no effect on sprinting and agility but a significant reduction in vertical jump performance. The current study, which used measuring techniques and bracing in accordance with Hawkey *et al.* (2007), show similarities with previous studies with regard to agility and sprinting performance, but showed no detrimental effect on jumping performance.

The non-significant effect in sprint performance reported in the current study could have been expected as previous research, using the same brace, has shown no reduction in sprinting performance (Hawkey and Scattergood, 2007; Hawkey *et al.*, 2007). The non-significant effect in agility performance reported in the current study is consistent with Hawkey *et al.* (2007) and may have been the result of a trade-off between the brace restricting range of motion suggested by Cordova *et al.* (2002), while also providing additional proprioceptive feedback as suggested by Papadopoulos et al (2005); essentially cancelling out these effects. Jump performance in the current study may have been expected to be reduced due to results of previous research, however this was not the case, and performance was not hindered as it was in studies by Paris (1992) and Hawkey *et al.* (2007). However, although Hawkey *et al.* (2007) reported a statistically significant difference in vertical jump height with the application of a brace, the actual difference in performance was only 0.01m.

Although not measured during the current investigation, previous research has highlighted a reduction in dorsi-/plantar-flexion (Simpson *et al.*, 1999), which may have been a factor in the jumping impairment reported by Hawkey *et al.* (2007). Therefore, it may be possible that soccer players initiate different jumping mechanisms to their basketball counterparts, and exhibit different levels of dorsi-/plantar- flexion. Despite using the same brace, the soccer players in the current study jumped 0.47m compared to the 0.58m performed by the basketball players in Hawkey *et al.* (2007). Future study should review this variable using motion analysis to determine ankle joint angles. However, it is possible that the reported disparities in jump height with bracing in previous studies could simply be attributed to either an inaccurate method of measurement, from presenting statistically but not practically significant results, or from variations in jumping ability and technique in different sports.

Although the current study did not investigate injury reduction, previous research conducted with identical brace conditions has shown significant reductions in injury incidence and injury risk through reduced medio-lateral ground reaction forces. This combined with the current study's findings provides players, coaches, and sports therapists with evidence supporting the use of external ankle supports.

Conclusion

The current study suggests that the application of a semi-rigid AircastTM AirsportTM ankle brace has no significant effect on soccer-specific performance. Taping of the ankle, while not affecting agility or jumping performance, did significantly reduce sprinting performance. Due to the previously reported superior injury reduction benefits and cost advantages of bracing over taping, the lack of expert training needed to apply bracing, and the issues with tape loosening over time, the current study provides evidence supporting the use of external ankle braces during soccer performance. Further research is now needed to establish how bracing affects range of motion, investigate comfort and compliance issues, and determine the long-term effects on injury risk, injury incidence, and soccer-specific performance.

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Figures

Figure 1: Graph showing agility performance in control, braced and taped conditions

Figure 2: Graph showing sprint performance in control, braced and taped conditions

Figure 3: Graph showing jump performance in control, braced and taped conditions

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Case Study

The effects of 12-weeks pre-season plyometric training on physiological fitness in ice-hockey: A case study on a national level hockey player

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KEY WORDS

Stretch Shortening Cycle
Power
Repeated Sprint Ability
Prehabilitation

ABSTRACT

Pre-season strength and conditioning programmes can be effective in enhancing an athlete's physiological capacity and reducing subsequent injury risk during the season. However, there is little data regarding physical preparation for ice-hockey athletes. Given that ice-hockey is a physically demanding sport it would be of value for scientists and practitioners to have access to successful conditioning programmes for this sport. The aim of this paper is to present results of a 12-week, pre-season, plyometrics-based intervention with a national level ice-hockey player using a single-subject design. The intervention resulted in a number of physiological changes specific to ice-hockey performance. Most notably, it enabled the athlete to increase anaerobic power production both on and off-ice, to complete repeated sprints with less decrement in performance and to increase anaerobic threshold compared with baseline scores. This data therefore suggests that pre-season plyometric training may be result in positive physiological changes specific to ice-hockey performance.

Introduction

Ice-hockey is a physically demanding sport characterised by high-intensity, intermittent movement (skating), rapid changes in direction and velocity and frequent body contact with opposing players. The main skills of the game must be executed at a high tempo with phases of play relying heavily on the ATP-PCr system (Vescovi et al., 2006; Green et al., 1987). From a performance enhancement perspective the challenge to scientists, therapists and associated professionals is to maintain the player's energy levels throughout the game and to maximise player potential through physical training that mirrors the frequent high-intensity movements used within ice-hockey (Montgomery, 2000).

Within ice-hockey, on-ice training is predominantly used for skill development purposes (Montgomery, 2000). As this is usually not sufficient to promote high level physical development, additional off-ice training/testing is used. Furthermore, one of the main aims of any ice-hockey training programme should be development of skating speed with plyometric cited as a major means to achieve this (Montgomery, 2000)

Plyometrics have been used widely to increase muscle force production, explosive power and speed (Hewett et al., 1996; Potteiger et al., 1999; Markovic, 2007; Bruce-Low and Smith, 2007) by means of the stretch shortening cycle. Plyometric training has also been advocated as a particularly useful method of training for ice-hockey (Twist, 2007). The purpose of plyometric training is to increase the power of movements by using the elasticity of muscles and tendons and the stretch reflex (Potach and Chu, 2008). Briefly, when an eccentric muscle action is performed the musculotendinous unit is stretched, this results in a lengthening of the series elastic component (SEC) of this unit. This acts like a spring and stores elastic energy. If a concentric muscle action immediately follows this action the stored energy is released which allows the SEC to contribute to total force production by naturally returning the muscles and tendons to their unstretched position (Potach and Chu, 2008). This coupled with stimulation of muscle spindles due to a rapid stretch results in a reflexive muscle action causes an increase in muscle force production.

However, although studies have reported on the impact of plyometric training in various sports, no studies appear to have reported its efficacy in preparing athletes for ice-hockey and there is a dearth of data relating to the physiology of and physical preparation in ice-hockey in general. Few papers have documented successful training techniques that could be used to effectively prepare ice-hockey athletes despite their being calls to do so (Montgomery, 2000; Bracko, 2001; Geithner et al., 2006). The aim of this case study is therefore to document the effect of a 12-week preseason plyometric intervention on a national level ice-hockey player.

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Athlete background

A 24-year-old national level ice-hockey player approached the author for physiological support shortly before preseason preparation. Discussions with the athlete revealed that he felt 'slower' around the ice, was increasingly 'losing challenges on the boards' and having difficulty avoiding opponents when on offence. He also felt that he was finding it harder to contend with the short but repeated, high-intensity bouts of skating necessary for a defenceman in ice-hockey. The client also expressed a wish to maintain body mass as he felt this gave him an advantage in checking opponents 'up the boards'.

Baseline data collection

After providing informed consent the client underwent physiological fitness testing to provide a baseline for any future intervention. All testing was carried out in accordance with the BASES guidelines for physiological testing (Winter et al., 2007) and took place on two mornings (separated by 72h). In addition, the applicant was able to conduct some on-ice speed testing prior to a team training session. This was not originally included as part of the battery of baseline tests due to issues getting access to the rink and distance of the rink from the client's home. This testing took place one week after the initial baseline testing session but before any intervention work had begun.

Stature and body mass were measured using a Seca stadiometre and weighing scales (Seca Instruments, Germany). Skinfold measures at five sites (tricep, bicep, sub-scapular, supra-illiac and mid-thigh) using Harpenden skinfold callipers. The Durnin and Womersley (1974) skinfold equation was used to determine percent body fat although the sum of all five skinfolds was also used 'to provide an overall and absolute measure of subcutaneous fat' in accordance with recommendations by (Eston, 2002, p369). Muscular strength was measured in three different ways. Due to its relationship with shot velocity, hand grip dynamometry (Takei Instruments, Japan) was used to assess grip strength. Measures of right and left grip were combined to provide an overall grip strength score as is conventional within the ice-hockey (Vescovi et al., 2006). Upper body strength was determined using the 150lb bench press test. This was used due to its prevalence as a test of muscular strength within the literature relating ice-hockey performance (Montgomery, 2000; Vescovi et al., 2006).

Explosive leg power was determined using a countermovement jump performed on a portable force platform (Kistler Quattro Jump, Kistler, Amherst, NY) at a sampling rate of 500 Hz. From this, jump height, peak power and mean power were determined directly from the force data.

VO2 max was assessed using a treadmill based test (Woodway PPS Med, USA) of maximal oxygen uptake using breath by breath gas analysis (Cortex, Metalyser 3B, Cortex biophysic, Germany). Anaerobic threshold was also determined from this test data using the ventilatory threshold (V-slope method). Speed over 10 and 30 metres was measured (7 repetitions with 25 seconds rest between sprint) in an indoor sportshall using electronic timing gates (Brower Systems, USA) from this fatigue index over 10 and 30 metres was calculated in accordance with protocols advocated by Reilly (2001). Although the latter test can be considered crude, it does provide a valid method for assessing the patterns of activity experienced in multiple sprint sports such as ice-hockey (Glaister, 2008).

In addition, on-ice speed was assessed using a 40.8m maximal skate to determine maximal skating speed (Bracko, 2001). On-ice anaerobic power was calculated from this using the regression equations of Watson and Sargeant (1986).

Intervention

Examination of baseline data coupled with discussions with the client and information based on background literature appeared to indicate that % body fat was higher than previous literature on either elite American or elite British Hockey players (Montgomery, 2000; Duncan et al., 2007). Coupled with this, values determined for VO2 max were similar to those for the general population. Specificity of testing in relation to ice-hockey may be an issue here but the VO2 max of 40 ml kg-1 min-1 would not be considered high for an athletic population. Finally, although the sprint times recorded are not poor the fatigue index (ie drop off in sprint performance) was relatively high. This also agreed with the subjective comments made by the client in their initial baseline discussions. The ability to make repeated short distance/duration sprints with as little drop-off in performance is particularly important in ice-hockey due to the need to perform these high intensity activities during the game (Montgomery, 2000; Vescovi et al., 2006). Based on this information, a 12-week intervention aimed at developing speed and explosive power was developed using plyometric training techniques. The intervention was designed in accordance with guidelines for athlete training in the preparatory period of a periodised training programme (Wathen et al., 2008).

The intervention took place twice weekly, with at least 48 hours between sessions after 2 technique-familiarization sessions. During the training program the participant also maintained his current ice-hockey specific training (2 on-ice skill development session per week). At the start of each session he completed a plyometric-specific warm-up (approximately 10 minutes) comprising submaximal drills over 15 m, as advocated by Potach and Chu (2008). The training program is presented in Table 1. It consisted of exercises designed to build start speed, acceleration, change of direction, and vertical jump. All drills used were categorized as low to moderate intensity, and each session comprised approximately 100 to 120 foot contacts (Chu, 1998). As few specific exercises were available for ice-hockey and due to constraints in terms of on-ice time, movements were adapted from plyometric drills originally developed for team games and for off-ice conditioning in ice-hockey (Twist, 2007; Chu, 1998). During each session a work/rest ratio of 1:5 seconds was used to aid correct execution of the movements by the client (Chu, 1998). After completing the 12-week intervention the client was reassessed using the same methods as for baseline data collection. Preintervention and postintervention data are presented in Table 2.

Table 1. The Training Programme

Warm-Up Exercise/Drill	**Repetitions**
Marching	2 x 15m
Toe-jogging	2 x 15m
Butt-Kickers	2 x 15m
Forward Lunging	2 x 15m
Skipping (low leg rise)	2 x 15m
Skipping (high leg rise)	2 x 15m
Carioca	2 x 15m
Main Programme Exercise/Drill	
Standing long jump	5
Multiple box to box jumps	5, over 3, 30cm boxes
Lateral Step Up	5, each leg
Front cone hops	5 x 15m
Lateral cone hops	5 x 15m
Cone hops with change of direction sprint	5 x 15m
Alternate bounding with one arm action	3 x 30m

Table 2. Pre and Post Intervention Physiological Data

Measure	**Baseline Value**	**Post Intervention Value**
Stature (m)	1.85	1.85
Body mass (kg)	110.6	109
Body fat (%)	22.1	19.8
Sum of 5 skinfolds (mm)	86.4	67.6
Grip Strength combined (kg)	101	104.2
150lb Bench Press (Reps)	7	9
Vertical Jump (cm)	42	47
Peak Power (W)	4707.8	5073.2
VO2 max (ml kg-1 min-1)	40	44.8
Anaerobic Threshold (%VO2 max)	58.3	63.3
Sprint Speed 10m (s) Quickest Time	2.05	2.00
Sprint Speed 10m (s) Mean Time	2.37	2.24
Sprint Speed 30m (s) Quickest Time	4.4	4.32
Sprint Speed 30m (s) Mean Time	4.75	4.63
Fatigue index 10m (%)	24.3	16.5
Fatigue index 30m (%)	20.2	18.1
On-Ice Speed (40.8m) (Secs)	5.47	5.22
On-Ice Anaerobic Power (W/kg)	6.71	6.96

Discussion

Comparison of pre to post intervention values indicates that the plyometric training programme had a positive impact on the client's physiological profile specific to ice-hockey.

Body mass decreased slightly as did percent body fat. The client's VO2 max values increased slightly and there was a significant improvement in anaerobic threshold (as measured by ventilatory threshold). However, these changes may also be partly attributable to the other elements of the client's training undertaken (as part of his normal pre season training) rather than the intervention itself.

The athlete's vertical jump score increased by 5 cm (11% increase) with a corresponding increase in peak power directly determined via force plate analysis. In regard to sprint speed over 10 and 30 metres the client has decreased his best sprint times marginally. What is of note is the change in fatigue index for both 10 and 30 metres following the intervention. However, the client's fatigue index improved following the plyometrics intervention. Moving from 24.3 % and 20.2% to 16.5% and 18.1% for 10 and 30 metres respectively. This would seem to indicate that although the athlete has not become particularly faster the plyometrics programme has resulted in the client being able to complete repeated sprints with less drop off in performance compared to baseline scores. This was also reflected in a reduced 20m on-ice skate time where performance was improved by 5% and an increase in on-ice anaerobic power. These results agree with prior studies of ploymetrics in field sports (Duncan, 2006) and this improvement may be beneficial to the client's hockey performance where repeated bouts of sprinting are necessary.

This study used a single subject research design in order to examine the extent to which this regimen worked for a specific athlete (Kinugasa et al., 2004) but additional research with a larger number of athletes would be needed to statistically support these findings. This case study also provides an example of an effective preseason training program that could be used with ice-hockey athletes.

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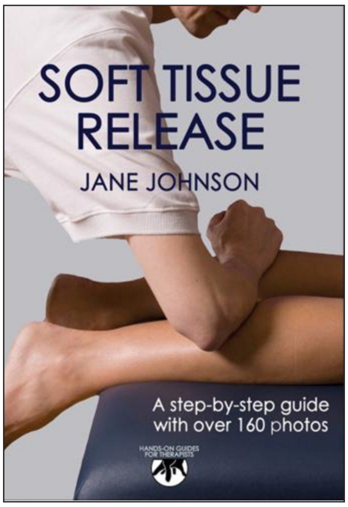

Book Review:

Soft Tissue Release

Jane Johnson
Publisher: Human Kinetics
ISBN: 978-0736077125
£14.99
2009

Sheila Leddington Wright
Coventry University

This is a well written basic book with clear guidelines on the methodology of soft tissue release (STR). This will equip the reader to be able to deliver this aspect of soft tissue massage. Written in 4 parts, starting with an introduction of basics of STR with explanations for the safety to therapist and clients when using this technique. Part 2 explains the methods of applications of STR and describes 3 methods, passive, active-assisted and active. Part 3 demonstrates and instructs for each area of the body where STR could be safely and effectively applied. Part 4 is a very useful assessment and documentation section with examples of client notes, rationale for questions.

The book is very well illustrated with good colour photographs. Each chapter has a question section at the end which ensures understanding for the student. There are tips about potential problems or difficulties peppered throughout Part 3, which facilitates a practical application understanding of the STR concept

There are no references to support this work and no mention of any research currently being undertaken, however I would recommend this for sports therapy students as a basic introduction and very useful handbook for reference.

It is part of a series of "hands on guides" for therapists.

Sheila Leddington Wright, April 2010

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