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Neuromuscular prevention program in female basketball players

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Neuromuscular prevention program in female basketball players

Thesis of

Roberto Benis

Aim

The overall purpose of this thesis was to obtain knowledge about individualised program for prevention lower limbs injuries in female basketball players.

In this thesis we presented three studies, about here, with main purpose of the investigations.

Study I

To examine the incidence of ACL injury in elite Italian basketball league.

Study II

Bodyweight neuromuscular intervention could improve performances on YBT in female basketball players in order to postural stability

Study III

The effects the specific prevention injuries warm-up designed for female basketball at

Abstracts of scientific studies

Study I: The incidence of ACL injury in elite Italian basketball league. (2014) Benis R.

***Objective*:** The aim of this study was to investigate a incidence of ACL injury in elite Italian basketball league.

Context. In female athletes and in particular in sport as basketball, ACL injury is the most frequent lower limb injury in basketball.

Design. An observational study with a retrospective case-series design

Participants. Thirty-two professional female basketball teams (n.234; age: 26±4 years old; body mass 70±7 kg; height: 1.78±6.8 cm; weekly training volume 12±2 hours) volunteered participated to the study.

Results. 65 basketball players in career had a least an ACL lesion (with surgical intervention), that represent 18.4% of the total players. ACL lesions were overall 74 (7 players suffered from 2 or more lesions).

The average of first ACL lesions was 19.6 ±4.2 years, age between 16-20 years old 34 ACL injury (52.3%) more frequent respect other groups.

We reported a prevalence of ACL lesion on game (72.9 %) respect to training (27%) Most of them were over the half of games and training (respectively 66.9 and 65%). We reported higher ACL lesion in second half of national championship (31 compared to 74 totals, 41:8 %) vs other part of basketball season. ACL lesions were 58 (78.3%) with non contact and 16 (21.6%) were with contact and the more frequent movement was occurred during turning movement (change of direction) (43.1%). Data are expressed as percent (%) and mean±standard deviation (SD).

Conclusions.

Results suggest that ACL injuries occur frequently in female basketball players. It’s very important to follow the prevention program routine , in particular in the childhood period and in puberty to educate players particularly young people and adult players for preserving their sport career. Further studies should investigate the effectiveness of prevention program routine to prevent ACL injuries.

Keywords. ACL injury, Basketball, Female athletes

Study II: Body weight neuromuscular training improves performance on Lower Quarter Y-Balance Test ™ in female National basketball players (2015) *Benis, R., M, Bonato., La Torre, A.*

Objective**:** The aim of this study was to investigate if bodyweight neuromuscular intervention could improve performances on YBT in female basketball players in order to postural stability and therefore a reduction of lower limbs injuries.

Context. Lower Quarter Y-Balance Test (YBT) is a functional and inexpensive postural control measurement tool that can identify individuals at an elevated risk of injury.

Design. 8-week longitudinal randomized controlled study.

Participants. Twenty-eight healthy female basketball players (age: 20±2 years old; body mass 63±7 kg; height: 1.72±0.07 cm; weekly training volume 7±1 hours) volunteered participated to the study. Subjects were randomized into training group (n=14) and control group (n=14).

Intervention. All subjects were tested at baseline and after 8 weeks of conventional basketball training program during the national regular season. In each testing session data on anthropometry and YBT were collected. The experimental group underwent instead of the standard warm-up, 30 min of body-weight neuromuscular training intervention using plyometric and core stability exercises, designed for improve lower extremity strength and core strength.

Results. Two-way repeated-measures analysis of variance of pre- and post-intervention values showed significant improvement in posteromedial (right, $P = 0.0487$; left, $P = 0.0383$) and posterolateral (right, $P = 0.0156$; left, $P = 0.0109$) reach direction and composite YBT scores (right, $P = 0.0004$; left, $P = 0.0011$) in the experimental group. No differences in anterior reach direction in either group were detected. Significant differences in posteromedial reach (right, $P = 0.0045$; left, $P < 0.0001$) and composite scores (right, $P = 0.0034$; left, $P < 0.0001$) between the experimental and the control group were noted

Conclusions. Bodyweight neuromuscular training improved postural control and lower limb stability as assessed with the YBT in female basketball players. Incorporating neuromuscular training in workout routines for basketball players may enhance joint awareness and potentially reduce the risk of lower extremity injury

Keywords. Body weight strengthening; core stability; plyometric exercises; composite score; lower limb stability.

Study III: Prevention of lower limbs injuries in youth female basketball players: A pilot study (2014) *Benis, R., M, Bonato., La Torre, A.*

***Objective*:** Aim of this pilot study was to investigate the effects the specific prevention injuries warm-up designed for female basketball athletes

Context: Basketball is one of the most popular sports, and it is also one of the highest contributors to sport and recreation-related injuries. As the sport grows, in terms of number of participants and intensity, so does the number of injuries. Female basketball players, compared to male athletes, are characterized by an increased risk of lower limbs injuries.

***Design*:** longitudinal controlled study.

Setting: Female team basketball: national level in Italy.

Patients or other participants: Eighty-six young, female, regional level basketball players (age 16±2 y-o; 52.9±11.4 kg; 160±1 cm; 20.1±3.1 kg/m^2) were enrolled in a 16-wks protocol consisting of 3 session/week of 2 hours.

Interventions: Consisted of education, stretching, strengthening, plyometrics, and sports-specific agility drills designed to replace the traditional warm-up.

Main Outcome Measures: The number of non contact injuries in lower limbs during the period study in compliance with prevention program.

Results: Experimental group had a incidence rate (IR) of 2,25 per 1000 hours exposure with a possibility of 0,69 to 3,80 on 1000 hours to incurring in a injury; Epidemiological incidence proportion (IP) was 0,18 with 0,07 to 0,30 risk of injury/athletes.

The control group had with an incidence rate (IR) of 4,61 per 1000 hours exposure with a possibility of 2,48 to 6,74 on 1000 hour to incurring in an injury. Epidemiological incidence proportion (IP) was 0,43 with 0,28 to 0,58. Relative risk of injuries is 0,51% less on IBIPP group respect to control group. Number Needed to Treat (NNT/NNH) rates was 3,7: absolute risk reduction (ARR) 0,27.

Experimental group showed significant improvements in CMJ (ES 0.8) one-legged CMJ right leg (ES 0,8) CMJ left leg (ES 0,6) and Y excursion balance test for both legs (ES 0,5-0,4) , compare the control group we didn’t find any significant differences.

Conclusion: The prevention program called I.B.I.P.P. through a neuromuscular warm-up specific for basketball , has shown to reduce the incidence of injuries non contact lower limbs in young female regional basketball players.

Keywords: Female basketball, Injuries prevention, incidence rate, risk of injuries.

Chapter 1

Introduction

Brief history of basketball

Basketball was invented in 1891 by James Naismith, a physical education teacher who recognized the need for an indoor sport during cold winter months. From simple beginnings, basketball has grown in popularity throughout the world. The International Basketball Federation is now comprised of 213 countries and reports that in 2006, 11% of the world played basketball (2008). Basket ball was played for the first time at the Olympic Games on August 1, 1936, in Berlin. Women's basketball joined the Olympic program in 1976.

Characteristics of the game

Basketball is played by two teams of five (5players each) The aim of each team is to score in the opponents' basket and to prevent the other team from scoring. The game is controlled by officials, table officials.

The team that has scored the greater number of points at the end of playing time shall be the winner. The game consist of four periods of ten minutes with an interval of play of twenty minutes and a intervals of play of two (2) minutes between the first and second period (first half), between the third and fourth period (second half). Overtime periods are five minutes in length.

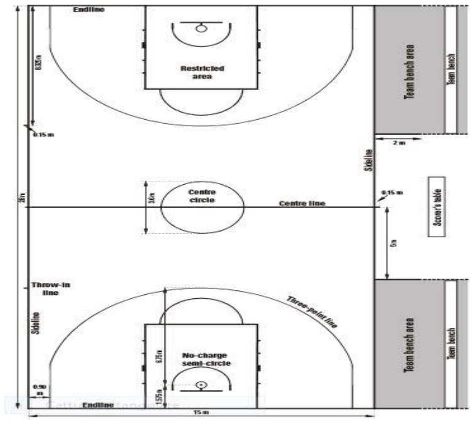

Figure: 1.2 -Full size playing court from OFFICIAL BASKETBALL RULES 2010 FIBA.

Basketball physiological model

Basketball is an aerobic-based anaerobic sport (Delextrat and Cohen, 2009; Meckell et al., 2009; Metaxas et al., 2009) which requires high intensity activities such as jumping (for rebounds, blocks and shots), turns, dribbles, sprints, screens and low intensity activities such as walking,
stopping and jogging. Frequent stoppages in games allow players to recover between bouts of activity, thus allowing repeated high-intensity spells of play (Drinkwater, 2008). Aerobic capacityis positively associated with recovery during repeated high-intensity bouts (Castagna et al., 2008; Tomlin and Wenger, 2001). Moreover, the high intensity movements of basketball players are closely related to the development of strength, speed and agility (Castagna et al., 2007; Hedrick, 1993; Meckell et al., 2009). During a basketball game, professional players cover about 3500- 5000m (Janeira and Maia, 1998).

Each player performs about 1000, mainly short, activities lasting around 2 seconds; time motion analysis has shown that these short activities are performed with a different frequency according to the player's position (Abdelkrim et al., 2007).

Explosive strength, take-off power, speed, and agility are abilities that make an important contribution to efficient movement with and without the ball, thus play an important role in basketball technique and tactics (Erculj et al., 2010).

Figure: 1.2 – A basketball players

Epidemiology of injury in basketball

Traditionally, basketball has been considered a noncontact sport, but there is now sufficient body contact to suggest that it has evolved into a semi-contact sport.

Overall Injury Rate

Overall Injury Rate there is a wide range in the overall rate of injury in basketball and considerable variation in how rates are reported (hours of participation, athlete exposures (AEs), athlete per season, participant years, percentage of players), which reflects characteristics of specific surveillance methods and designs. Table1.1 summarizes injury rates and design parameters (retrospective, prospective) of basketball injury studies. The definition of a reportable injury can influence the injury rate reported. Definitions comprised of "any injury receiving attention" capture minor injuries that do not result in time lost from participation and produce higher injury rates as compared with definitions based on "time lost from participation." These minor injuries cloud our understanding of the risk associated with playing basketball. For example, McKay et al. (2001b) used a definition of "any injury receiving treatment" and found a rate of 23 to 26.9 per 1,000 hours of participation. However, applying a "time-loss" definition resulted in a rate of approximately 6 per 1,000 hours.

In general, most epidemiologic studies in basketball report a relatively low injury rate. The highest rate of injury is reported in professional American basketball (19–25 per 1,000 AEs). Other rates vary from 1.4 to 9.9 injuries per 1,000 AEs, depending on the definition used and the population sampled.

Table 1.1 - Overall injury rates in basketball.

Study	Design	Duration	Sample	Per 1,000 Hr	Per 1,000 AE	Other Rates
Agel et al. (2007)	R	16 yr	College			
Female					7.7[a]	
Dick et al. (2007)	R	15 yr	College			
Male					9.9[a]	
Deitch et al. (2006)	R	6 seasons	NBA and WNBA			
Male—game-related					19.3[b]	
Female—game-related					24.9[b]	
Meeuwisse et al. (2003)	P	2 yr	College			
Male					4.9[b]	
McKay et al. (2001b)	P	17 mo	Adults			
Male—elite				26.9[b]	26.9[b]	
Male—recreational				22.0[b]	14.7[b]	
Female—elite				23.0[b]	23.0[b]	
Female—recreational				25.7[b]	17.2[b]	
Sallis et al. (2001)	R	15 yr	College			
Male						126.9/100 players/yr
Female						112.0/100 players/yr
Stevenson et al. (2000)	P	5 mo	Adults—recreational	15.1[a]		
Starkey (2000)	R	10 yr	NBA			
Male					21.4[a]	
Arendt & Dick (1995)	R	5 yr	College			
Male				5.6[a]		
Female				5.2[a]		
Crawford & Fricker (1990)	R	8 yr	Elite (16 to 23 yr)			
Female						0.8 participant-years[a]
Lanese et al. (1990)	P	1 yr	College			
Male				4.5[b]		
Female				4.8[b]		

AE - athlete exposure; NBA -National Basketball Association; P -prospective; R -retrospective; WNBA Women's National Basketball Association. a Any reported injury. b Time loss from reported injury

Injuries anatomical localization

Basketball requires repetitive jumping interspersed with running and rapid change of direction, and this pattern is indicated in the lower limb being more affected by injury than the upper limb. Table 1.2 details the distribution of injuries by body region. The lower limb accounts for 46.4% to 68.0% of injuries, while head and neck injuries were responsible for 5.8% to 23.7%. Upper-limb injuries account for 5.6% to 23.2% of injuries, and spine and pelvis injuries for 6.0% to 14.9%.

Table 1.2 - Percent distribution of injuries by anatomical location

Study	Head/Neck %	Spine/Pelvis %	Upper Limb %	Lower Limb %	Other %
Agel et al. (2007)	14.7	7.4	14.1	60.8	3.0
Dick et al. (2007)	13.9	11.4	14.1	57.9	2.7
Deitch et al. (2006)				65.0	
Meeuwisse et al. (2003)	10.2	6.5	13.5	67.4	2.3
McKay et al. (2001b)	23.7	6.3	23.2	46.8	
Starkey (2000)	8.5	9.5	12.1	46.4	23.5
Crawford & Fricker (1990)	9.6	14.6	5.6	66.0	2.2

The most common specific injuries have been detailed in several studies providing more information about specific anatomical sites of injury. Studies reporting injury location-by-type data are summarized in Table 1.3. The most common lower-limb injuries in basketball occur at the ankle and knee. The prevalence of ankle injuries varies between 10.7% and 76.0% of all injuries, at rates between 1.5 to 4.3 per 1,000 AEs and 5.2 to 5.5 per 1,000 hours of participation. The rate of knee injury has been reported between 1.5 and 4.4 per 1,000 AEs and is the most frequent injury reported in professional American basketball players, accounting for 20% of all injuries (Figure ….1) (Deitch et al. 2006). Anterior cruciate ligament (ACL) damage is a common knee injury, which is often season-ending or, at times, career-ending. Because of its serious nature, several studies have specifically investigated the rates of ACL injuries in basketball , which vary from 0.03 per 1,000 AEs in a male sample (Agel et al. 2005) to 0.48 per 1,000 AEs in a female sample (Gwinn et al. 2000). Knee-extensor injuries mostly affect the proximal end of the patellar tendon in basketball players and account for approximately 70% of patellar tendon injury (Blazina et al. 1973). Although dental injuries are thought to account for only 1% of basketball-related injuries, they are of concern because they can be permanent, disfiguring, and expensive (Labella et al. 2002). Cohenca et al. (2007) conducted a retrospective review of records and reported the incidence of traumatic dental injuries for male and female college basketball players as 10.6 and 5.0 per 100 athlete-seasons, respectively

Table 1.3 -Frequency and rates for common location-by-type injuries.

	Ankle Ligament Sprain		Knee Internal Derangement		Knee		Patella or Patellar Tendon		Upper-Leg Contusion		Lower Back Strain		Nose—Fracture		Head—Concussion	
	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs	%	Per 1,000 AEs
Agel et al. (2007)[a]																
Female	24.6	1.9	15.9	1.2			2.4	0.2	1.7	0.1	1.3	0.1	1.7	0.1	6.5	0.5
Dick et al. (2007)[a]																
Male	26.2	2.3	7.4	0.7	1.5	0.1	2.4	0.2	3.9	0.3	2.2	0.2	1.7	0.2	3.6	0.3
Deitch et al. (2006)[b]																
Male	17.9	3.5	0.7	0.1	19.1	2.5	4.3	0.8	3.5	0.7	4	0.8	1	0.2	1.2	0.2
Female	17.3	4.3	1.6	0.4	22.5	4.4	4.7	1.2	2.6	0.7	2.8	0.7	1	0.3	2.4	0.6
McGuine & Keene (2006)[a]	8.1	1.5														
Mihata et al. (2006)[b]																
Male			1.4	0.08												
Female			5.2	0.28												
Trojian & Collins (2006)[b]																
Caucasian				0.45												
African-American				0.07												
Agel et al. (2005)[a]																
Male				0.03–0.13												
Female				0.20–0.37									0.03–0.13			
Beynnon et al. (2005)[a]																
Male		0.4/PD														
Female		1.9/PD														
Meeuwisse et al. (2003)[b]																
Male	15.8		1.9						3.3						3.7	
McKay et al. (2001b)[b]	21.1	3.9			13.7	2.5										
Gwinn et al. (2000)[a]																
Male				0.09[a]												
Female				0.48[a]												
Hosea et al. (2000)[a]																
	76.0			For females RR, 3.0; $P < 0.001$												
Starkey (2000)[a]							3.3									
Male	16.1	3.4					0.7		6.9	1.5	4.4	0.9	0.8	0.2		
Sallis et al. (2000)[a]		2.9/PY				1.7/PY										
Arendt & Dick (1995)[a]																
Male			1.2	0.07[a]												
Female			5.7	0.29[a]												
Leanderson et al. (1993)[b]		5.5/Hrs														

AE - athlete exposures; Hr - rate per 1,000 playing hours; PD -rate per 1,000 person-days; PY - rate per 1,000 participant-years; RR risk ratio. a Any reported injury. b Time loss from any reportable injury

Environmental Location

<u>Competition versus Training</u>

More injuries are sustained during competition than during training sessions. In a 16-year review of men's college basketball in the USA, Dick et al. (2007) found that the rate of injuries in games was two times greater than in practice (9.9 per 1,000 AEs vs. 4.3 per 1,000 AEs; rate ratio, 2.3; 95% CI, 2.2– 2.4). In a similar review of women's college basketball, Agel et al. (2007) reported the same findings (7.7 per 1,000 AEs vs. 4.0 per 1,000 AEs; rate ratio, 1.9; 95% CI, 1.9–2.0). Meeuwisse et al. (2003) reported that 3.7 times more serious injuries occurred in collegiate basketball games (1.9 per 1,000 AEs) as compared with training sessions (0.5 per 1,000 AEs). Agel et al. (2007) reports that female college players were more likely to sustain a concussion (rate ratio, 3.3; 95% CI, 2.8–4.0), knee internal derangement (rate ratio, 3.3; 95% CI, 2.9-3.7) and ankle sprain (rate ratio, 2.0; 95% CI, 1.8–2.2) in a game than in training. In professional American basketball, (Deitch et al. (2006) reported that female players were injured more frequently at practices as compared with games, while Starkey et al. (2000) reported that 43.2% of injuries in male players over a 10-year period occurred during a game.

When Does Injury Occur

Injury Onset

Although few studies differentiate between acute and overuse injuries it appears that overuse injuries account for between 12.8% and 37.7% of all injuries. Tendinopathies, particularly patellar tendinopathy, are the most common overuse injury. All players are vulnerable, particularly those that are aerial players by nature. Cook et al. (1998) reported a prevalence of patellar tendinopathy diagnosed on imaging in basketball players of 50%. About one third of athletes with patellar tendon changes had imaging abnormalities bilaterally

Chronometry

Few studies have investigated the time during a game at which injury occurs. McKay et al. (2001a) found no significant relationship between time during a game and ankle injuries. Three studies have investigated the time during a basketball season during which injury is most common and shown have a higher rate in the preseason as compared with later in the season for both practice and games. In men’s collegiate basketball, Dick et al. (2007) reported that the preseason injury rate in practice (7.5 per 1,000 AEs) was almost three times higher than the in-season practice injury rate (2.8 per 1,000 AEs) (rate ratio, 2.7, 95% CI, 2.6–2.8), which was, in turn, 50% greater than the postseason rate of training-related injuries (1.5 per 1,000 AEs) (rate ratio, 1.9; 95% CI, 1.5–2.3). For game related injuries, the in-season rate (10.1 per 1,000 AEs) was 1.6 times higher than the postseason rate (6.4 per 1,000 AEs) (rate ratio, 1.6; 95% CI, 1.3–1.9). Comparable findings were documented in women’s college basketball. Agel et al. (2007) reported that the preseason training-related rate (6.8 per 1,000 AEs) was more than twice as high as during in season training (2.8 per 1,000 AEs) (rate ratio, 2.4; 95% CI, 2.2–2.4), and the regular season game rate (7.7 per 1,000 AEs) was significantly greater than that for the postseason (5.5 per 1,000 AEs) (rate ratio, 1.4; 95% CI, 1.2–1.7). Stevenson et al. (2000) reported that the injury rate in Australian basketball players was the highest at the start of the season (20 per 1,000 hours) and then significantly declined by the end of the fifth month (10 per 1,000 hours). Starkey (2000) reported that game-related injuries in professional American basketball increased by

12.4% over a 10-year period. In contrast, Agel et al. (2005) showed that over a 16-year period the game injury rate in female collegiate players had an average annual decrease of 1.8% (P 0.04), and the rate of injury in training sessions had an average annual decrease of 1.3% (P 0.05). No changes were reported over the same period in men's collegiate basketball, either during games (0.8%, P 0.28) or training sessions (0.0%, P 0.98) (Dick et al. 2007).

Results of injuries

Injury Type

Table 1.4.summarizes the percentage distribution of type of injury incurred by basketball players. In general, sprains are the most common type of injury, often accounting for about half the injuries. Other common injuries are contusions and strains.

Table 1.4 - Percent distribution and rate for injury type

	Sprain		Strain		Contusion		Overuse		Dental		Other	
	%	Injury Rate per 1,000 AEs	%	Injury Rate per 1,000 AEs	%	Injury Rate per 1,000 AEs	%	Injury Rate per 1,000 AEs	%	Injury Rate per 1,000 AEs	%	Injury Rate per 1,000 AEs
Rechel et al. (2008)												
Male	52.6				18.1							
Female	59.3				6.7							
Deitch et al. (2006)												
Male	37.0	7.2	16.4	3.2	20.4	3.9					1.7	0.3
Female	40.4	10.1	15.2	3.8	19.9	5.0					1.9	0.5
McKay et al. (2001b)	51.6	9.4			25.3	4.6					9.5	1.7
Starkey (2000)	20.9	7.4	16.2	4.1	11.8	4.5			0.9	0.2		
Chan et al. (1993)	55.5		7.1		9.1		16.9				11.4	

Time Loss

There is considerable variation in how time loss due to injury and the severity of injury are recorded in basketball studies, making it difficult to give a clear overview. Agel et al. (2007) reported that approximately 25% of game and training injuries caused 10 days to be missed. In a study of elite and recreational Australian basketball players, McKay et al. (2001b) reported that 17.8% of injuries (2.9 per 1,000 AEs) resulted in 1 week away from participation. Other studies have assessed time loss and severity of injury in terms of the need for surgery or hospitalization. In professional American basketball players, Starkey (2000) reported that 3.7% of players required surgery (1.8 per 1,000 AEs), which accounted for 28.4% of the total days missed. Knee injuries appear to be responsible for the most time lost, and they required surgery more often than other injuries. In intercollegiate players, Agel et al. (2007) reported that knee internal derangement injuries accounted for 41.9% of game-related and 26.1% of training-related injuries in which10 days of participation were lost and, on average, knee injuries caused 18.3 days to be missed (Meeuwisse et al. 2003).

In professional players, knee injuries were responsible for 13.6% of days lost, and the patellofemoral joint accounted for 13.1% of days lost (Starkey 2000).

Ankle injuries also cause substantial time to be missed. Agel et al. (2007) reported that ankle injuries accounted for 13.2% of game-related and 11.5% of training-related injuries, for which 10 days participation were lost. McGuine and Keene (2006) found that 29% of ankle injuries caused 8 to 21 days to be missed and another 6.4% caused 21 days to be missed. In a sample of Australian players, McKay et al. (2001b) noted most time lost was due to ankle injuries, accounting for 43.3% of injuries for which 1 week was missed, with these injuries occurring at a rate of 1.3 per 1,000 AEs. Meeuwisse et al. (2003) reported that ankle injuries caused, on average, 5.5 days to be missed, while McGuine and Keene (2006) reported a mean of 7.6 days.

In a largely recreational sample, in which 66.3% of the players were over the age of 25 years, McKay et al. (2001b) reported that calf injuries were second to ankle injuries for time lost, accounting for 16.7% of injuries for which 1 week was missed, at a rate of 0.5 per 1,000 AEs.

In professional American players, injuries to the lumbar spine were the third most common injury to cause days to be missed, accounting for 11.0% of all time missed. Tendinopathy, once it progresses past self management, can result in extended periods during which the player is unable to train or play. A study of recovery from patellar tendinopathy indicated that more than 33% of players were unable to play for more than 6 months and 18% for 12 months (Cook et al. 1997).

Clinical Outcome

Recurrent injuries are common in basketball. For example, DuRant et al. (1992) reported that 66.7% of athletes who injured their ankles had a history of ankle sprain, and follow-up of ankle injuries after 6 to 18 months have shown that residual ankle symptoms occur in 40% to 50% of cases. Konradsen et al. (2002) found that 7 years after injury, 32% of injured players continued to report residual ankle symptoms. Recurrent injuries in basketball also involve the knee (DuRant et al. 1992; Meeuwisse et al. 2003), elbow (Meeuwisse et al. 2003), shoulder (DuRant, 1992), hand (Meeuwisse et al. 2003), lumbar spine/ pelvic region (Meeuwisse et al. 2003), leg (DuRant et al. 1992), and concussion (Meeuwisse et al. 2003). Catastrophic injuries are defined by the National Center for Catastrophic Sports Injury Research (NCCSI 2004) in the United States as those that result in a brain or spinal cord injury or skull or spinal fracture and subclassified as fatalities, nonfatal (permanent severe functional disability) and serious (no permanent functional disability

Risk Factors of injuries

Intrinsic Factors

Intrinsic risk factors implicated in basketball injuries are detailed in the following section. The effect of these factors may be mediated by extrinsic factors, particularly load, and there are few clear cause-and-effect relationships with injury.

Sex

Although a number of studies have found a higher overall rate of injury in female players as compared with male players (in professional American basketball, e.g., Deitch et al. 2006), most have reported no significant differences (Arendt & Dick, 1995; McKay et al. 2001a; Sallis et al. 2001). However, specific sex-related injuries have been noted. For example, Deitch et al. (2006) found that female professional American basketball players sustained significantly more sprains as compared with male players. More importantly, Agel et al. (2005) determined that female players were more than three times as likely to incur an ACL injury as compared with their male counterparts (rate ratio, 3.6; 95% CI, 3.0–4.2), and Gwinn et al. (2000) showed a similar trend (ACL injury rates in women, 0.5 per 1,000 AEs as compared with 0.1 per 1,000 AEs in men; rate ratio, 5.4, P 0.05). Previously presented sex-related sociocultural differences, including women having less experience in organized sports or being less fit, do not seem to be important. For example, Mihata et al. (2006) showed no change in the rate of ACL injuries per 1,000 AEs in male and female basketball players over a 15-year period (1989–1994: women, 0.29; men, 0.07; 1994–2004: women, 0.28; men, 0.08) despite improvements in these characteristics. Similarly, Agel et al. (2005) showed no change in the rate of ACL injury over a 13-year period in female (0.27 per 1,000 AEs) and male (0.08 per 1,000 AEs) basketball players. Cook and colleagues (1998, 2000) have found that men may be at greater risk for patellar tendinopathy, documenting considerable prevalence differences between men (42%) and women (18%).

Level of Competition

There is uncertainty regarding whether level of competition is a risk factor for injury in basketball. Dick et al. (2007) reported significantly higher game related injury rates in Division I men's collegiate basketball (10.8 per 1,000 AEs) than in Division III (9.0 per 1,000 AEs) (rate ratio, 1.2; 95% CI, 1.1–1.3) but not for Division II. Agel et al. (2007) found differences between all three levels in collegiate women: Division I as compared with Division II (8.9 vs. 7.4 per 1,000 AEs; rate ratio, 1.2; 95% CI, 1.1–1.3), and Division III (8.9 vs. 6.6 per 1,000 AEs; rate ratio, 1.3; 95% CI, 1.3–1.5). In contrast, an Australian study reported no difference in the game-related injury rate between elite (men, 26.9 per 1,000 hours of participation; women, 23.0 per 1,000 hours) and recreational players (men, 22.0 per 1,000 hours; women, 25.7 per 1,000 hours) (McKay et al. 2001a).

Previous Injury

The most commonly documented intrinsic risk factor for ankle injury is a history of ankle sprain (Table 6.6). In the earliest of these studies, Garrick and Requa (1973) reported a significantly higher rate of ankle injury in those with a history of ankle injury (27.7 per 1,000 AEs) as compared with their previously uninjured counterparts (13.9 per 1,000 AE; P 0.025). McGuine and Keene (2006) documented the risk of sustaining an ankle sprain to be twice as high for players who had sustained an ankle injury in the previous 12 months (rate ratio, 2.14; 95% CI, 1.3–3.7) and McKay et al. (2001a) reported that players with a history of ankle sprain were almost five times more likely to injure their ankle as those without a history of ankle injury (rate ratio, 4.9; 95% CI, 2.0–12.5). Evidence shows that combinations of intrinsic risk factors may have a cumulative effect on the risk of ankle injury. For example, overweight male athletes (body-mass index 95th percentile) with a previous ankle sprain were 9.6 times (McHugh et al. 2006) to 19 times (Tyler et al. 2006) more likely to sustain a noncontact ankle sprain as compared with normal-weight players without a history of ankle sprain.

Table 1.5 - Intrinsic risk factors of ankle injury

Risk Factor	Study	Results
Nonmodifiable		
Being female	Beynnon et al. (2005)	RR, 1.5; 95% CI, 0.8–2.9
	Hosea et al. (2000)	RR, 1.3; $P < 0.001$
Modifiable		
History of ankle injury	Garrick & Requa (1973)	27.7 (history) vs. 13.9 per 1,000 AEs; $P < 0.05$
	McGuine & Keene (2006)	RR, 2.1; 95% CI, 1.3–3.7; $P = 0.005$
	McHugh et al. (2006)	1.2 vs. 0.3 per 1,000 AEs; $P < 0.05$
	McKay et al. (2001a)	RR, 5.0; 95% CI, 2.0–12.5; $P < 0.001$
	Tyler et al. (2006)	2.7 vs. 0.4 per 1,000 AEs; $P < 0.001$
Abnormal body sway/balance	McGuine et al. (2000)	Injury rate, 2.7 (high sway) vs. 0.4 (low sway) per 1,000 AEs; $P < 0.0002$
	Wang et al. (2006)	Anteroposterior sway (RR, 1.2; $P = 0.01$); mediolateral sway (RR, 1.2; $P < 0.001$)
Weight (heavier athletes at increased risk)	McHugh et al. (2006)	Injury rate for BMI ≥95th percentile, 3.0 per 1,000 AEs; vs. <95th percentile, 0.8 per 1,000 AEs; $P < 0.05$
	Tyler et al. (2006)	2.0 (overweight) vs 0.5 (normal weight) per 1,000 AEs; $P = 0.04$

BMI = body-mass index; RR = rate ratio.

Trojian & Collins (2006) determined that white female players were 6.6 times more likely to injure their ACL than were black female players (0.45 per 1,000 AEs vs. 0.07 per 1,000 AEs; rate ratio, 6.6, 95% CI, 1.35–31.73).

Balance

Although balance has been examined as a risk factor in youth and adolescent basketball injury (e.g., Plisky et al. 2006, Wang et al. 2006) no such studies have involved adult players.

Injury Score

Using a sample of 45 basketball players, Shambaugh et al. (1991) showed that logisticregression analysis incorporating three structural measures [weight imbalance (lateralization of center of gravity) 0.36 abnormal right quadriceps angle 0.48 abnormal left quadriceps angle 0.86 intercept (7.04)] correctly predicted the injury status of 91% of players. However, Grubbs et al. (1997) applied this injury equation to 62 highschool basketball players and found it to have no predictive value.

<u>Extrinsic Factors</u>

Playing Position

Limited research has investigated whether playing position is a risk factor for injury. Early studies were descriptive in nature but concluded no such relationship (Henry et al. 1982), which has been supported by more recent research on both overall injury rate (McKay et al. 2001a) and risk for ankle injury specifically (Leanderson et al. 1993; McKay et al. 2001b). In contrast, Meeuwisse et al. (2003) showed that centers had a higher injury rate for knee (rate ratio, 13.0), ankle (rate ratio, 4.5) and foot (rate ratio, 10.0) injuries as compared with forwards, who had the lowest rate.

Shoes

McKay et al. (2001a) reported that basketball players wearing more expensive shoes, which had air cells in the heel, were 4.3 times more likely to injure their ankle than those wearing less expensive shoes (rate ratio, 4.4; 95% CI, 1.5–12.4; P 0.01).

Events inciting injuries

Player contact was responsible for 52.3% of game related injuries in male collegiate players (Dick et al. 2007) and 46.0% of injuries in female players (Agel et al. 2007) and was the most common mechanism for ankle injuries in both. Meeuwisse et al. (2003) documented a ratio of 4:3 for contact to noncontact injuries also in college players. In an Australian sample, McKay et al. (2001b) reported that 52.1% of injuries were due to body contact but that almost half (45.0%) of the ankle injuries were incurred during landing and another 30% sustained while doing a cutting maneuver. ACL injuries have been reported as non-contact injuries in 65.2 % of male college players and 80.1% of female college players (Arendt & Dick 1995). Although Krosshaug et al. (2007) found that a majority (71.8%) of ACL injuries were from noncontact mechanisms, they reported perturbation of a movement pattern in the time before injury for many cases. These researchers conducted video analysis of 39 ACL injuries (22 in women, 17 in men) and found that one half (11 of 22) of the ACL injuries in women involved the player being pushed or collided with before the time of injury. A majority (71.8%) occurred while the injured player was in possession of the ball, and over half (56.4%) occurred while attacking. For female players, 59.1% of ACL injuries occurred during single-leg landings, while in male basketball players 35.3% occurred during single-leg landing.

Injury Prevention

As detailed previously, the two most problematic injuries in basketball are related to the ankle and knee (ACL). As a result, greater emphasis on prevention of these injuries is evident in the literature.

Ankle Injuries

Injury-prevention strategies for the ankle have traditionally included the use of external ankle supports (braces or tape), high-cut shoes and functional rehabilitation programs.

External Ankle Support

The use of external ankle support as a protective factor for ankle injuries is well documented in the literature. External ankle support includes the use of both ankle braces and ankle tape. Four systematic reviews, analyzing between 5 and 14 randomized, controlled trials (RCTs) have concluded that ankle braces decrease the incidence of ankle injuries (Handoll et al. 2001; Quinn et al. 2000; Verhagen et al. 2000). Handoll et al. (2001) conducted a meta-analysis using 14 RCTs (8,279 participants) and reported a reduction in the number of ankle sprains with the use of external ankle braces (rate ratio, 0.53; 95% CI, 0.40–0.69). This reduction was greatest in those with a history of ankle sprain (rate ratio, 0.33; 95% CI, 0.20–0.53). Handoll et al. (2001) concluded that there is good evidence that ankle braces provide protection for athletes involved in sporting activities considered to present a high risk for ankle injuries, such as basketball.

Functional Rehabilitation

McGuine and Keene (2006) reported that a balance training program (balance board and singleleg functional exercises) significantly decreased the risk of ankle sprains in high-school basketball players as compared with a control group (1.13 per 1,000 AEs vs. 1.87 per 1,000 AEs; P 0.04). Beyond this study, there appears to be a lack of basketball-specific research to demonstrate functional rehabilitation as a protective factor for ankle injuries.

Anterior Cruciate Ligament Injuries

Basketball players followed the Sportmetrics and the KLIP training programs (Hewett et al. (1999 Pfeiffer et al. 2006). The Sportmetrics was a multi component program, while the KLIP a plyometric based training program supplemented by agility training and instruction on correct technique. Sportmetrics included aspects of strength training, flexibility, plyometrics as well as education and feedback on correct technique .

Running exercises were also performed as a warm up before the execution of the main part of the training program The time needed for training was 20 min (Pfeiffer et al., 2006) and 60e90 min (Hewett et al., 1999) respectively. KLIP was performed in season (Pfeiffer et al. 2006) used 9-week while the Sportmetrics, used 6-week was conducted in the preseason (Hewett et al. 1999).
Participants in both studies were non elite athletes in their mid teens (14e18 years). Both programs failed to have a significant reduction of ACL injuries in basketball athletes.
In particular Hewett et al. (1999) reported that the rate of noncontact ACL injury decreased by 72% in the intervention group (rate ratio, 0.50; 95% CI, 0.1–2.5).

Figure: 1.3 – A basketball action

Injury Surveillance Systems

There is an ongoing need to develop more comprehensive injury surveillance systems in basketball at all levels of participation with a standard definition of a reportable injury and denominator data (exposures) for expressing injury rates. Consistent injury surveillance systems would enable comparisons across studies to be readily made and provide a clearer understanding of injuries in varying basketball populations around the world. Further research also needs to examine factors such as age, sex, level of experience, and position played on the court, for not only the overall injury profile but also to improve the understanding of specific injuries. The reasons for injuries being more prevalent in the preseason as compared with later in the season also need to be established, and whether a pattern exists as to when injuries occur during games needs to be clarified. There also needs to be more widespread reporting of catastrophic injuries to enable risk factors and preventive strategies to be developed for these life-changing events. Regarding the major injury categories of ankle and knee injuries, further research of ankle injuries should include investigating the mechanisms of ankle injuries and their role in preventing these injuries, identification of other risk factors for ankle injuries, the role of the sole of the basketball shoe in respect to proprioceptive feedback, and the rate of ankle injury (Robbins and co-workers found that the thickness and hardness of the soles of shoes affected foot position under dynamic conditions, with the thickest and softest soles causing the greatest errors [Robbins et al. 1995; Robbins & Waked 1998]), the impact of functional rehabilitation programs in reducing the risk of ankle injury, clarification of the specific role of ankle taping or bracing in preventing ankle sprains, and the utility of improving physical fitness/conditioning as an effective injury prevention strategy

Further research into ACL injuries in basketball should include exploring and confirming risk-factors (including race), determining whether the addition of unexpected changes to normal movement patterns during training improved landing strategies, or whether neuromuscular training programs can decrease the risk of ACL injury in players of varying levels of experience, age groups, and ethnic groups. For example, Krosshaug et al. (2007) found that female players land with more hip and knee flexion and, as a result, were 5.3 times more likely to sustain a valgus collapse than male players (rate ratio, 5.3; P 0.002). In addition, Chandrashekar et al (2005) argued that the female ACL has a smaller cross-sectional area (mean SD: in female players, 58.29 15.32 mm2 , in male players, 83.54 24.89; P 0.007), is shorter in length (in female players, 26.85 2.82 mm; in male players, 29.82 2.51; P 0.01), and has a smaller volume (in female players, 1954 516 mm3 ; in male players, 2967 886; P 0.003) as compared to the male ACL. The association of these differences with ACL injury has yet to be substantiated in the epidemiologic literature. Interestingly, Lombardo et al (2005) reported that an 11-year prospective study investigating 305 professional male players showed no significant difference in intercondylar notch width index between players with ACL injuries (0.235 0.031) and those without ACL injuries (0.242 0.041) players (t305 0.623; P 0.534).

Finally, although tendinopathy is currently subject to extensive research at molecular, histologic, and clinical levels, it would be reasonable to say that this research has not yet delivered substantial changes in management. For example, Gaida et al. (2004) found that athletes who had patellar tendinopathy trained for a mean (SD) of 2.6 1.4 hours more than athletes without tendinopathy but the importance of load, as measured by frequency or volume of participation, has not been adequately explored. Better understanding of tendon pathology, improved exercise options, and understanding those at risk are key to improving management. Most importantly, identifying the source of pain is critical, followed by research that allows the matrix to fully restructure after injury.

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Chapter 2

Knee injuries in sport

The knee is one of the most commonly injured joints in the lower limb and frequently accounts for the greatest loss of training and playing time (Agel et al., 2007; Dallalana et al.2007; Starkey, 2000). Knee injuries typically account for 15-25% of all injuries in high school, college and professional players of football, basketball, floorball, Australian Rules football, volleyball and rugby (Agel et al., 2007; Dallalana et al., 2007; Deitch et al.,2006, Le Gall et al 2008; Rauh et al., 2007; Starkey, 2000). In addition, knee injuries can result in individuals being unable to return to sport, developing OA or having to change employment (Myklebust et al., 2003b; Utting et al., 2005).

Frequency and causes of knee injuries in women

Women are typically at least twice as likely to suffer ACL (anterior cruciate ligaments) injury as men (Agel et al., 2005; Arendt, et al; 1995, Boling et al., 2010; Deitch, et al. 2006; Myer et al., 2008)

This may be due to a number of factors including, increases in frontal and transverse plane hip and knee joint angles and decreases in hip muscle strength and activation compared to men (Beutler at al. 2009; Decker et al., 2003; Willson et al;2006). Despite higher injury rates in women, there are likely to be common factors which may increase injury risk in both men and women.

Altered neuromuscular control (NMC) of the lower limb during these movements has been suggested as an important component of such injuries (Hewett, Myer, & Ford, 2006b) ACL injuries as patella-femoral joint injuries (other frequent injury of overuse in the knee) are thought to be the result of poor neuromuscular control during common tasks such as running, jumping and landing (Dierks, et al. 2008; Souza et al.2009a).

Knee injuries in basketball

Injuries to the knee are less common than ankle injuries in basketball. However, knee injuries are generally more devastating to the athlete because they are associated with a greater loss of playing time (Zvijac et al. 1996). Knee injuries have received a tremendous amount of attention over the last few years. This is a result of a clear difference in injury patterns between male and female athletes. With the increase in the number of female athletes participating in intercollegiate athletics since the 1970s female athletes have been suffering knee injuries in a disproportionate number. In a 5-year study on NCAA College basketball players 12% of all injuries recorded for men were knee injuries, while injuries to the knee accounted for 19% of the total injuries in women (Arendt et al .1995). During this time period the knee injury rate for men was 0.7 injuries per 1000 athlete exposures, while for women it was 1.0 per 1000 athlete exposures. The knee structures that were injured can be seen in Table 2.1 The structure most frequently injured for the male athlete was the patella or patella tendon, while anterior cruciate ligament (ACL) and meniscus injuries were the most common in the female athlete.

Table 2.1 -Knee structures most commonly injured in the male and female basketball player. (Data from Sitler *et al.* 1994.)

Males		Females	
Injury	**% Occurrence**	**Injury**	**% Occurrence**
Patella or patella ligament	38	Anterior cruciate ligament	26
Collateral ligaments	31	Torn cartilage	26
Torn cartilage	20	Collateral ligaments	25
Anterior cruciate ligament	10	Patella or patella ligament	22
Posterior cruciate ligament	1	Posterior cruciate ligament	1

ACL injury

Injury to the knee joint complex is one of the most common in sport (Hootman, Dick, & Agel, 2007; Starkey, 2000). In particular, injury to the anterior cruciate ligament (ACL) is responsible for a significant amount of time-loss in sport. (Starkey, 2000) ACL injuries can result in inability to return to previous activity levels and both injuries are associated with early onset of knee osteoarthritis (OA) (Lohmander et al. 2007; Lohmander et al.2004).

Olympic Committee current concept, risk factors for female athletes suffering ACL injury include 1) being in the pre-ovulatory phase of the menstrual cycle, compared with the postovulatory phase; 2) having a decreased intercondylar notch width on plain radiography; and 3) the development of an increased knee abduction moment (a valgus intersegmental torque) during impact onloading.(Reinstrom et al 2008).

Thus, sex hormones, dynamic neuromuscular imbalance, and anatomy may play a role in the increased risk of non-contact ACL injury in female athletes. (Dugan 2005)

ACL injury mechanism

To prevent noncontact ACL injuries in female athletes, it is critical to understand the mechanisms that cause these injuries. Shimokochi et al. found multiplane (sagittal, frontal, and transverse) knee loadings were the primary mechanism in a recent review of various research methods studying noncontact ACL injury mechanisms, with the highest ACL loads incurred during a knee valgus load combined with knee internal rotation and quadriceps force application with insufficient hamstrings cocontraction at or near full knee extension .

These findings were reinforced in separate retrospective video analyses of ACL injuries, which proposed evidence that support 2 predominant loading patterns: (a) anterior tibial shear and (b) injury as a result of ''knee valgus collapse'' (defined as a combination of knee valgus, hip internal rotation, and tibial external rotation) near full extension and foot planted during deceleration (Ireland et al. 2002; Quatman et al 2008; Shultz 2008).

Cadaveric studies indicate that a combination of forces, specifically with increased knee valgus loads, directly elicit higher strain on the ACL than isolated motions and torques. (Alentorn et al.2009; Lloyd et al.2001; Markolf et al. 1978; Myer et al. 2007; Withrow et al. 2006).

These force combinations are consistent with the multiplane loading injury mechanism findings of Shimokochi et al. and sufficient to trigger ACL tearing (Alentorn et al. 2009; Lloyd et al. 2001 , Markolf et al 1978; Myer et al 2007; Withrow et al. 2006).

These force combinations most commonly occur during athletic tasks involving deceleration, change of direction, and jump landings. Biomechanical and neuromuscular differences at the trunk and lower extremities during these sport tasks are believed to be the most likely factors to account for the significant bias in noncontact ACL injury rates in women vs. men (Herman et al. 2009).

A video analysis study indicates a frontal plane “valgus collapse” mechanism for non-contact ACL injury in women. (Quatman et al 2008).

Non-contact ACL injuries often exhibit a common body posture that involves a valgus collapse of the knee joint, with the knee near full extension (between 0º and 30º) and an external tibial rotation with the foot planted during a deceleration maneuver. (Boden2000; Krosshaug 2007). Dynamic valgus collapse is the most common ACL injury mechanism for female handball and basketball players. Female basketball players have a 5.3-times higher relative risk of valgus collapse during ACL injury, compared with male basketball players. (Krosshaug 2007)

The majority of ACL injuries occur through non-contact and overuse mechanisms (Agel et al.2005; Finestone et al. 2008; Olsen et al.2004) which are widely regarded as avoidable if injury mechanisms and risk factors can be identified and preventative measures taken.
Non-contact ACL injuries commonly occur during decelerating manoeuvres such as cutting/turning and landing. (Boden et al. 2000; Boden et al. 2009; Krosshaug et al., 2007a).

Figure 2.1 - Image of ACL injury

ACL injuries in basketball players

The higher incidence of ACL injuries in female basketball players is a medical issue that has been seen in several studies in a number of different sports (Arendt et al.1995; Arendt et al. 1999 Gwinn et al. 2000; Hutchinson et al. 1995).
 Injuries to the ACL during basketball appear to occur with no apparent contact or collision with another player (77% of all cases including men and women) (Arendt & Dick 1995). The mechanism

behind these noncontact injuries appears to be the same in both men and women. Planting and pivoting movements appear to be the primary mechanisms reported for noncontact ACL injuries. Table 2.2 shows the common mechanisms reported for ACL injuries during basketball.

Injury occurs when the athlete lands in an uncontrolled fashion with their upper leg and hips adducted and internally rotated, their knee is extended or only slightly flexed and in a valgus position, and their tibia is externally rotated. Contact with the ground is made with the athlete not in control or well balanced. The positioning of these anatomical structures upon landing is known as the point-of-no-return and is thought to be primarily responsible for the noncontact ACL injury common to the basketball player (Ireland 1999).

Table 2.2 - Common mechanisms causing ACL injuries during basketball. (Data from Arendt *et al*. 1999.)

Mechanism	% Occurrence
Planting/pivoting	57.2
Hyperextension	12.3
Landing from a jump	12.2
Deceleration	12.2
Going up for a jump	4.1
Unsure	2.0

In National Collegiate Athletic Association (NCAA) injury data spanning 1990–2002 reports that the rate of ACL injury was significantly higher for female collegiate basketball players than males (Agel et al., 2005). The majority (ranging from 64.3 per cent to 89.7 per cent of total depending on the year) of ACL injuries sustained by female collegiate players were the result of non-contact mechanisms.

In particular the incidence rates in women's football and basketball range from 0.13-0.22 per 1000 exposures (Agel et al., 2005; Hewett et al., 1999) in a non-contact ACL injury

In the Women's National Basketball Association (WNBA) athletes experienced a game-related ACL injury rate that was 4 times that male's players of the National Basketball Association (NBA) and, overall, experienced a rate 1.6 times that of their NBA counterparts. The relatively low frequency of these injuries during the study period in both leagues may have prevented the difference from reaching statistical significance. Although ACL injuries tend to be the focus of study and media attention, the rate of occurrence across the 6 years of this study serves as evidence of the rarity of this event, representing 36 (0.8%) of the 4446 reports submitted between the 2 leagues.

The effect of prior attrition cannot be discounted when examining the differences in ACL injury between NBA and WNBA players. The higher rate of ACL injury in female high school and college athletes could result in the premature termination of careers that would otherwise include the professional ranks. The low occurrence of ACL sprains could also be reflective of the strength, conditioning, and training programs used to prevent this injury (Deitch et al 2006).

The incidence of game-related knee injury was higher in Women's National Basketball Association players. The incidence of anterior cruciate ligament injury in the National Basketball Association (number 22, 0.8%) and Women's National Basketball Association (number 14, 0.9%) accounted for 0.8% of the 4446 injuries reported. (Deitch et al 2006).

Figure 2.2 - Knee incident

Study I

The incidence of ACL injury in elite Italian basketball league

Introduction

Anterior cruciate ligament (ACL) tear, is one of the most common knee injuries in sports (McCarthy, et al; 2013; Yu & Garrett, 2007), usually occurring in a multitude of sports such as basketball, soccer, handball, alpine skiing and tennis (Bahr & Holme, 2003; Paszkewicz et al;, 2012). Extrapolating the data of a study to the whole US collegiate population, an annual average of more than 2000 ACL injuries in 15 different sports has been reported (Hootman et al.2007). A 2-8 times higher incidence of ACL injury in female compared to male athletes has been documented (Agel et al. 2005; Arendt & Dick 1995; Bjordal et al.1997; Hootman et al. 2007; Mountcastle et al. 2007) therefore a significant amount of research is focusing on female participants of various ages and sports (Myer et al. 2013; Sugimoto et al.2012).

A difference in ACL incidence rates has been reported for both sexes for different sports. Specifically, for females the injury rate-reported in number of injuries/1000 athlete-exposures (1 exposure ¼ 1 game or practice) was 0.28 for soccer, 0.23 for basketball, relatively smaller for volleyball (0.09) and the highest for gymnastics (0.33) (Hootman et al.2007).

Methods

Subjects

The sample population in this survey comprised 32 teams and 352 basketball players, who played in the elite Italian basketball professional division during the 2013-2014 seasons.

All the teams, 32 agreed to participate and verbal information was given to each team coach.

All players received and signed an informed consent approved by Italian basketball federations, Rome (Italy) which stated how the subject’s rights would have been protected.

The teams were introduced to the survey at the begin of the season, through their team coach, and the data were collected retrospectively. Written information was given to each player and informed consent was obtained.

The inclusion criteria were elite female basketball players included in the regular team line-up (including substitutes). Participant demographics are presented in table 2.3

Table 2.3 – Participant demographics

Level of play	Height (H) (cm)	Body Weight (BW) (kg)	BMI (kg/m2)	Age (Years)
A1-A2	1.78±6.8	70,9± 7.3	21.2± 2.1	26.1± 4.7

Legend: *Mean ± standard deviation (SD) of the results.*

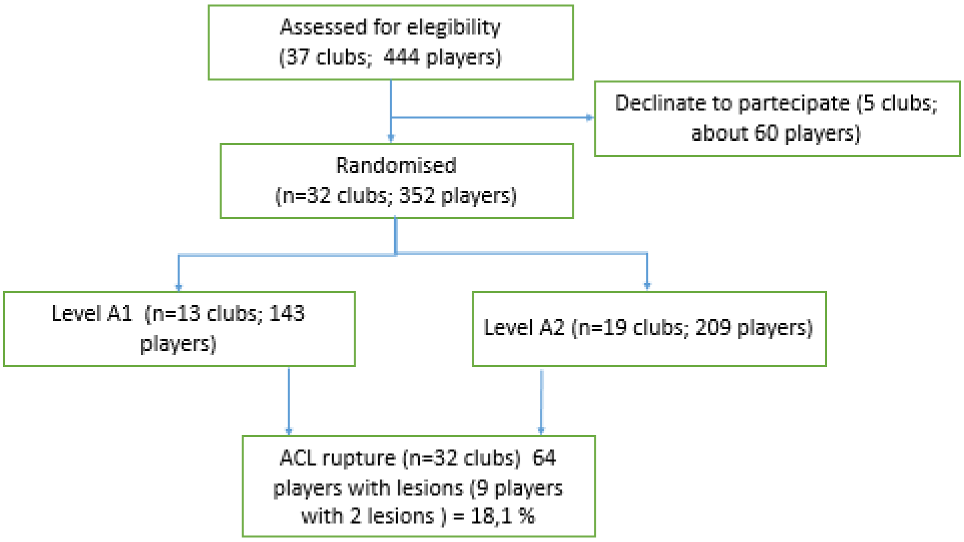
The basketball athletes were divided into 5 groups (5 years plot) that correspond to the chronological age groups:
Group 1: Aged from 11-15 years (mean of begin activity to young national league)
Group 2: Aged from 16-20 years (mean of end of puberty to begin professional basketball activity)
Group 3: Aged from 21-25 years
Group 4: Aged from 26-30 years
Group 5: Aged from 31-… years

Biological age of the athletes was not measured because they were selected only by chronological age for the competitions.

Experimental Design

32 professional basketball team received an invitation to participate in the study during the begin of season 2013-2014. The teams was organised by the Italian basketball Federation, female section. The team were recruited from June to August 2013 through a letter with information about the purpose and the design of the study went to the coaches, who also informed the players. (flow-chart figure 2.3).

Figure 2.3 - Flow of club clusters and players through the study



ACL injury registration

In that study we used a retrospective questionnaire for injury ACL data collection.

The physiotherapists, or strength and conditioning coach or a volunteer from each team was responsible for the distribution and subsequent collection of the questionnaires and for ensuring that the questionnaires were returned by post or e-mail to the author.

The questionnaire included data relating to team affiliation and the players' gender, age, weight and height and position. Each player was also asked to report the number of years of basketball play, the injured player's court position, the anatomical localisation of the injury and injury modalities , injury occurred during training or a match and time of accident. Furthermore period of seasons and movement that caused the injury.

The questionnaire based on FIBA injury surveillance was designed by the first author (R.B.) and final version of the questionnaire was then constructed and used in the present study.

The skill terminology was thought to be familiar to the players and, as a result, it was not defined in the questionnaire answered by the players.

Individual ACL Injury Report Form

In appendices

Data Analysis

Descriptive information about the injuries was based on information gathered from the questionnaire. Data are expressed as percent (%) and mean±standard deviation (SD).

The statistical tests were performed using Graph Pad Prism Software, version 6.00 for Mac OSX (Graph Pad Software, San Diego California USA).

Results

<u>Number of Acl lesion</u>: Of the 352 basketball players participated a research , a total of 74 Acl lesion was reported. 65 players had at least one ACL injury (rupture) (18.4%) and 9 players two or more ACL lesions (12.1% of players with Acl injury experience had a re-injury).

<u>Age of injury</u>: The average of first ACL injury (rupture) was 19.6 ±4.2 years. In particular: in group 1 (age 10-15 years old) 9 ACL injury (13.8%); in Group 2 (Age 16-20 years old) 34 ACL injury (52.3%), in Group 3 (Age 21-25 years old) 11 ACL injury (16.9%), in Group 4 (Age 26-30 years old) 11 ACL injury (16.9%), in Group 5 (Age 31-…. years old). 0 ACL injury (0%)

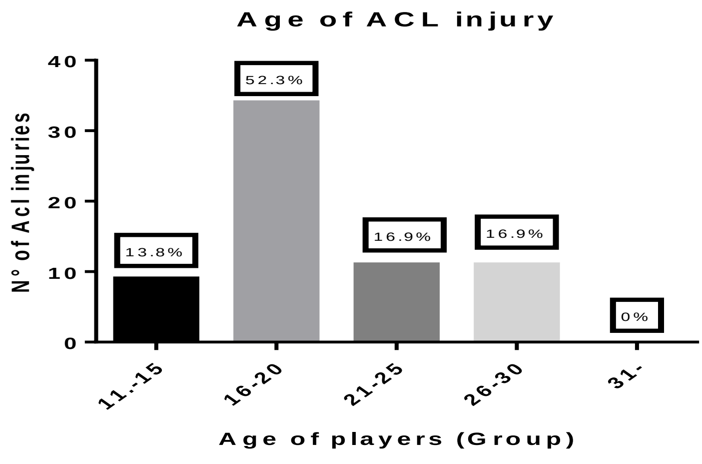


Figure 2.4 – Age of injury (group)

Legend: *Numbers, age (years) and percent(%) of ACL injuries*

Limbs of injury: We reported 33 ACL injuries on right limb (44.5%) and 41 in left limb (55.4%).

Competition versus training and timing: In our research we reported: On game vs to training, 54 injuries against 20, corresponding to 72.9 % respect to 27%. In second part of basketball training we reported 13 injuries (65%) while 7 (35%) was recorded in first part of training. In the game the incidence was 66.9 % in second part of game (3°-4°quarter). In warm-up and 1° e 2° quarter the incidence was 33,1%. (Figure 2.4-2.5-2.6)

Table 2.4 ACL injury timing

Injury occurred during		Moment of injury in training		Moment of Injury in match				
Match	Practice	1° Part	2°Part	Warm-up	1° Quarter	2° Quarter	3° Quarter	4° Quarter
54(72,9%)	20 (27%)	7 (20%)	13 (65%)	/	6 (11%)	12 (22%)	18 (33%)	18 (33%)

Legend: *Numbers and percent(%) of injuries*

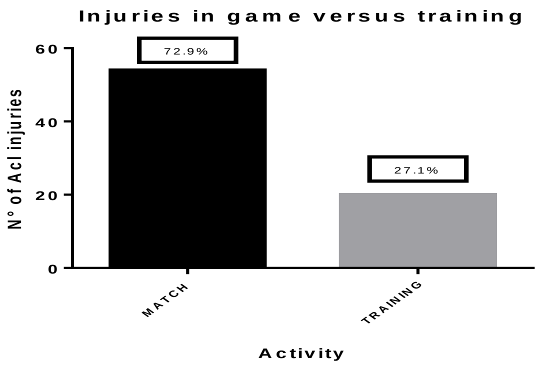


Figure 2.5 ACL injury in games and in training

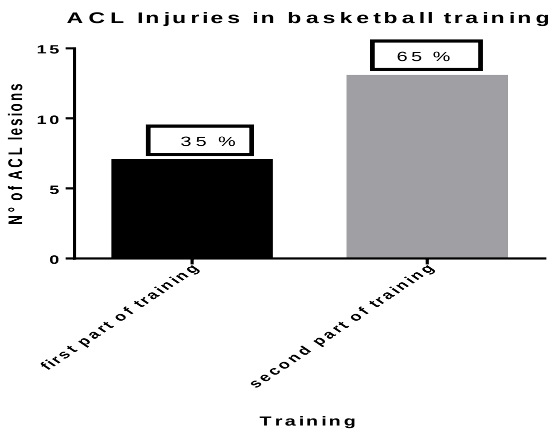


Figure 2.6 - ACL injury in basketball training (timing)

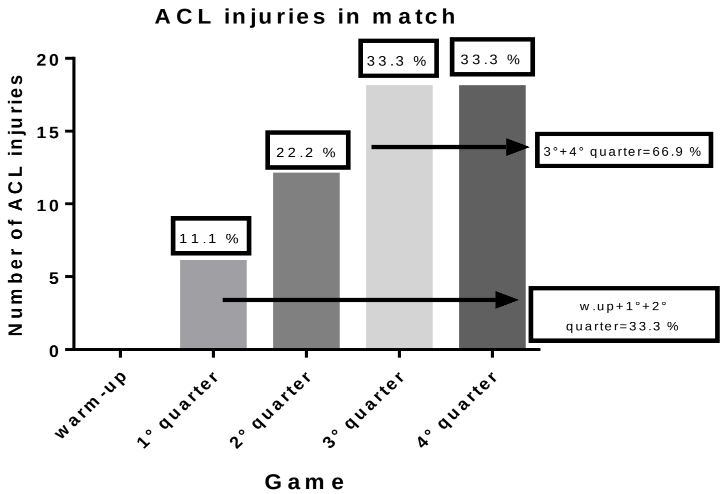


Figure 2.7 - ACL injury in match (timing)

<u>Period of injury</u>: Injuries occurred in pre-season (13 , 17.5%) in first part of national championship (15 , 20 %) in second part of national championship (31 compared to 74 totals, 41:8 %)_during to play-off/out (10, 13.5%) in national team season tournament (3, 4.5%) and off season period (2, 2.5%). (Table 2.5-figure 2,7)

Table 2.5 – Period injury (basketball season)

Period of injury					
Pre-season	1°Part of championship	2°Part of championship	Play-off	National team	Off season
13 (13%)	15 (20.1)%	31 (41.8%)	10 (13.5%)	3 (4.5%)	2 (2.5%)

Legend: *Numbers and percent(%) of injuries*

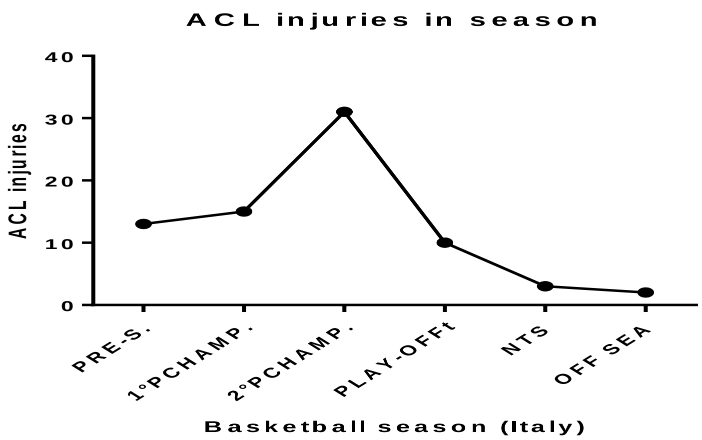


Figure 2.8- Trend of ACL injury in basketball season

Legend: Pre-season (Months: August to September) first part of national championship (Months: October to December) Second part of national championship (Months: January to April) Play-off/Play-out (April to May) National teams season (June-July).

<u>Injury mechanism and basketball movements:</u> We found that ACL lesions was 58 (78.3%) with no contact and 16 (21.6%) was with contact. _In total 74 ACL lesions 25 (43.1%) occurred during turning; 19 (32.7%) occurred during landing and 8 (13.7%) during stopping. 6 incident in other situation (10.3%). (Figure 2.8).

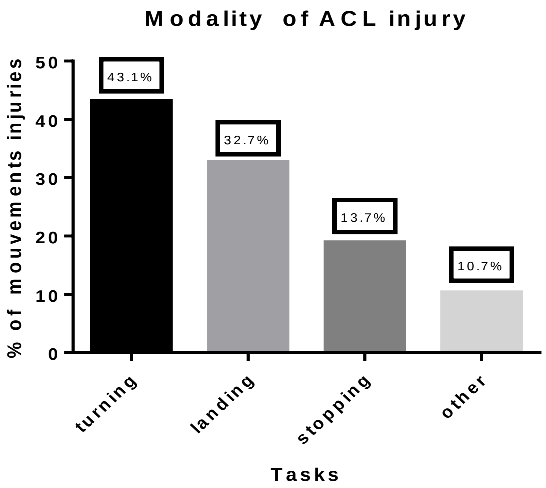


Figure 2.9 – Modality of ACL injury

Players position in the teams

We reported 37 injuries in Guards (with 4 re-injuries) 23 in Forward (with 3 re-injuries) and 5 in Center (with 1 re-injury).

Discussions

First issue of this questionnaire was in investigate on how many female professional basketball players have had a ACL lesion during their career .

Secondary outcomes was investigate on age of first ACL injuries, injuries in competition versus training , timing of ACL lesions and period of season and mechanism of incident.

About the main aim, we recorded 65 players (overall 352 players) with ACL injury (rupture and surgery reconstruction) with 9 players with one re-injury. **This research is the first data collection regard number of ACL lesion in female basketball in Italy; there wasn't' research with data collection about it questions , to date.** So far, no comparable epidemiological research has been utilized for investigate a number of Acl injury in Italian basketball professional league.

Deicht et al (2006) in a study about USA basketball, reported that the WNBA(Women National Basketball Association) athletes experienced a game-related ACL injury rate that was 4 times that of the NBA and, overall, experienced a rate 1.6 times that of their NBA counterparts. The relatively low frequency of these injuries during the study period in both leagues may have prevented the difference from reaching statistical significance. Although ACL injuries tend to be the focus of study and media attention, the rate of occurrence across the 6 years of this study serves as evidence of the rarity of this event, representing 36 (0.8%) of the 4446 reports submitted between the 2 leagues.

Instead the higher rate of ACL injury in female high school and college athletes could result in the premature termination of careers that would otherwise include the professional ranks. The low occurrence of ACL sprains could also be reflective of the strength, conditioning, and training programs used to prevent this injury (Deitch et al 2006).

Trojian et al (2006) in a retrospective study shows that the anterior cruciate ligament tear rate for White European American players was 0.45 per 1000 athletic exposures, whereas tear rates in the Women's National Basketball Association vary by racial group, with White European American players having more than 6 times the anterior cruciate ligament tear rate of other ethnic groups combined (Troijan et al. 2006).

Puberty has been associated with deficits, delays, and regressions of neuromuscular function, and many sex-related differences emerge that have been correlated with ACL rupture (Chandy et al 2007; Chaudhari et al 2007;Ford et al 2010).
Regard an age of first ACL injury, Di Stefano et al. 2010, Shea et al (2004) Yu et al. (2002a) underscores as ACL injury incidence was highest number occurs in ages 16 to 18 years.

In recent study of Ito et al (2015) reported a higher proportion of ACL injury in female players than in male players was recognized in the 10–19-year-old age group (45.9% vs 22.1%). Ito in according with literature (Arendt at al 1995, Messina et al 1999) suggesting the presence of a sex-specific difference in ACL injury in young athletes, including basketball players. (Ito et al 2014)

We recorded, in Italian professional league, 19.6 ±4.2 years the age of first ACL injury (with age of begin to play basketball was 9.5 years±4.3) but the higher slot was to 16-20 years old with 34 ACL injury (52.3%) and 9 and 11 injuries in slot 10-15 years old and 21-25 and 26-30 age years old slots.

With in recent years the frequency of ACL injury in young athletes has been increasing steadily around the ages of 10–12 (Mc Carthy et al 2012; Mizuta et al 1995). Each authors sustain an ACL rupture are at a high risk for developing knee osteoarthritis as early as 10 years after injury (Mc Cain et al 2011, Lohmander et al 2007; Lohmander et al 2004).
We underline as the movement patterns play a critical role in ACL injury because they influence anterior tibial shear force, which directly strains the ACL. Late childhood (age, 10–12 years) is a

critical period for refining movement skills because of steady and gradual growth (Giannotti et a.l 2009; Jurimae et al. 2000).
Therefore, this may be an ideal time to intervene in movement modification during sport-specific tasks to reduce future injury risk.

We underline as sex differences exist in knee abduction during landing: female athletes land with a greater total valgus motion and a greater maximum valgus knee angle than male athletes. (Ford et al. 2003) With the onset of puberty, marked changes in anatomy and posture occur in both males and females. Sex differences in femoral anteversion, the tibiofemoral angle, and the quadriceps angle emerge during puberty, with females maintaining a more inwardly rotated hip and valgus knee posture at full maturity.(Shultz 2008)
Thus, puberty-related increases in valgus knee angle and subsequently landing with greater valgus knee motion are considered to increase the risk of ACL injury in the 10–19-year-old age group of female basketball players. (Ford et al.2003; Shultz et al 2008; Ito et al. 2014).
That indications ad results underline the importance of prevention strategy and education in youth and in particular in female players.

About the limbs of Injury higher incidence of injury in left limb respect to right (only in first injury) with 33 ACL injuries on right limb (44.5%) and 41 in left limb (55.4%). Further researches will inspect about this information.

In our research we reported that more incident of ACL are reported on game respect to training (54 injuries against 20, corresponding to 72.9 % respect to 27%) in according with Murphy at al. (2003); Myklebust et al. (2003). Myklebust et al (2003) introduces the hypothesis that the level of competition, the way in which an athlete competes, or some combination of the two increases an athlete’s risk of suffering an ACL injury.

The risks of injury was more in match, In a 16-year review of men’s college basketball in the USA, Dick et al. (2007) found that the rate of injuries in games was two times greater than in practice (9.9 per 1,000 AEs vs. 4.3 per 1,000 AEs; rate ratio, 2.3; 95% CI, 2.2– 2.4). In a similar review of women’s college basketball, Agel et al. (2007) reported the same findings (7.7 per 1,000 AEs vs. 4.0 per 1,000 AEs; rate ratio, 1.9; 95% CI, 1.9–2.0).

Different results reported Deicht et al. (2006) where in professional American basketball, (Deitch et al. (2006) reported that female players were injured more frequently at practices as compared with games, while Starkey et al. (2000) reported that 43.2% of injuries in male players over a 10-year period occurred during a game.

The higher rate of injury seen during games is likely related to the greater levels of intensity, competitiveness and contact that occur in games compared to practices. We suppose the that reasons could have an influence on ACL injuries.

More injuries occurred in second part of basketball training, 13 (65%) while in the match the incidence was 66.9 % in second part of game (3°-4° quarter respect a warm-up and 1° e 2° quarter where the incidence was 33,1%),

That results underline the difference about the injury in basketball activity, the second part or training and game the athletes suffer a major ACL injury rate. The cause could be the fatigue, about LCA injury in female athletes Kernozeck (2007) reported as a neuromuscular fatigue caused significant alterations in landing mechanism , that may be indicative of the noncontact anterior cruciate ligament injury mechanisms.

The Italian basketball federation divided a basketball season in: Pre-season (Months: August to September, about 6-8 weeks) first part of national championship (Months: October to December, about 12 weeks) Second part of national championship (Months: January to April, about 12 weeks) Play-off/Play-out (about 4 weeks) National teams season (Months May-June or June-July, about 5-8 weeks) Off season (Months: May-July or June–July, about 12 or 8 weeks).

We analysed of period of ACL injury, we reported that more injuries occurred in second part of national championship (31 compared to 74 totals, 41:8 %; respect to first part of national championship (15 , 20 %) pre-season (13 , 17.5%) play-off/out (10, 13.5%) and National team season tournament (3, 4.5%) and finally off season period (2, 2.5%).

If we analysed the season activity we noted that as the period of January to May (second part of season about 16 weeks) reported more ACL rupture respect to period of August to December (first part of season about 18-20 weeks) with 41 lesions vs 28 lesions , respectively 55.4% vs 37.8%.

Other and future investigations need for detect the reason of this results.

We found that ACL lesions was 58 (78.3%) with no contact and 16 (21.6%) was with contact. Furthermore respect a total of 74 Acl lesions, 25 (43.1%) occurred during turning (change of direction, plant and cut), 19 (32.7%) occurred during landing (land after jump shot, rebound or lay-up) 11 (18.9%) during stopping (defensive slide, stop for jump) and 3 incident in other situation (5.1%). That result was in according with literature; indeed the majority of ACL injuries occur during a non-contact situation, approximately each 70% (Mc Nair et al 1990) typically during decelerating movements such as landing and cutting (Boden et al.2000; Boden et al.2009; Krosshaug et al.2007a McNair et al. 1990; Noyes 1983)

Women are twice as likely to suffer a non-contact ACL injury than men (Agel et al.2005; Arendt et al.1999; Deitch et al.2006). Typical non-contact ACL injury incidence rates in women's football and basketball range from 0.13-0.22 per 1000 exposures (Agel et al.2005; Hewett et al.1999). Women exhibit abnormal or poor neuromuscular control, often characterised by the presence of dynamic knee valgus, during landing and cutting manoeuvres (Herrington & Munro 2010; Kernozek et al. 2005) . It has been postulated that this contributes to greater incidence of ACL injury when compared to men.

That outcome and previous considerations confirm an importance of prevention injuries program, especially in young females athletes (Hewett et al. 1999, 2005,2006; Mandelbaum et al.2005; Hewett et al.2006; Pfeiffer et al. 2006; Zazulak et al.2007).

In basketball there are three main types of players (playing positions). We generally divide them into guards, forwards and centres, according to their playing tasks and the roles they have on the court and according to their playing position in offense.
Most injuries were reported to occur in the 'key' area of the court and of all the playing positions, the most injuries were recorded by centres (Meeuwisse et al.2003).

In our research we reported a prevalence on ACL injury by guards players. Other research will be necessary for have more information about this question.

Conclusions

Results suggest that ACL injuries occur frequently in female basketball players. It's very important to follow the prevention program routine , in particular in the childhood period and in puberty to educate players particularly young people and adult players for preserving their sport career. Further studies should investigate the effectiveness of prevention program routine to prevent ACL injuries.

Chapter 3

Study II

Bodyweight neuromuscular training improves performance on the Y-Balance Test in elite female basketball players

Introduction

Basketball is one of the world's most popular physical activities. According to the International Basketball Federation (FIBA), at least 450 million people from licensed players to amateurs play basketball worldwide. Although basketball is not strictly considered a contact sport, the lower limb joints are constantly subjected to physical stress from technical movements and intense physical interactions during a match (Cumps et al 2007) . McInnes et al. (1995) identified different types and intensities of activities and movement patterns, including quick and frequent running movements, shooting, direction changes and jumps, that changed every 2 seconds during "live time"; they estimated that a mean total of 105 ± 52 high-intensity runs (mean duration 1.7 seconds) recorded in a game translate into one high-intensity run every 21 seconds during "live time".

Despite the development and implementation of prevention activities, lower limb and ankle injury rates obtained through sports injury surveillance systems remain high in basketball players (Harmer et al 2005; Starkey et al 2000) . Drakos et al. (2010), in their descriptive epidemiological study of National Basketball Association (NBA) athletes, highlighted that injuries sustained in 17 championship seasons involved the lower limbs in 62.4% of cases, with the ankle the most commonly injured site (14.7%), followed by the spine and the knee. Prospective studies have reported that previous injury (Starkey et al 2000) , biomechanical alignment, anatomical factors (Drakos 2010), decreased muscle flexibility (Witprouw 2000), and poor balance (McGuine et al 2000) are all common risk factors for lower limb injuries in basketball players. Moreover, injury rates are higher among female players than their male counterparts due to sex-related neuromuscular imbalances, including ligament dominance, quadriceps dominance and leg dominance (Zelisko 1982). Specifically, women have a 2 to 8 times higher rate of anterior cruciate ligament (ACL) injury than men (Agel. et al 2005) . Zelisko et al. (1982) compared the injury rate between men and women in professional basketball and found that women sustained 60% more injuries to the knee and the ankle than men.

Among other risk factors, lack of neuromuscular control of the lower limbs has been associated with knee and ankle injuries. Considered a critical component of motor skills (McGuine et al.2000), neuromuscular control is defined as the ability to maintain the body's center of gravity within its base of support. It can be categorized as either static or dynamic balance (and may be the most modifiable risk factor in the prevention of knee injuries (Hewett et al.2005). Neuromuscular training programs have proven effective to reduce the risk of lower extremity injuries in a variety of sports (Caraffa et al.1996; Hewett et al.1999; Witprouw et al.2000). Studies on interventions that target improving neuromuscular control have demonstrated improvements in dynamic lower extremity alignment upon landing from a jump, shock attenuation of peak landing forces, muscle recruitment patterns, and postural stability or balance (Hewett et al.2005).

Neuromuscular training-prevention programs differ in design concept and type of exercises, including plyometric exercises, strengthening, balancing, endurance and stability (Hewett et al.2005; Mandelbaum et al. 2005; Zazulack et al. 2007; Gribble et al.2009).Such programs often entail the use of Swiss balls, medicine balls, and unstable bases; however, their practicality for many individuals, teams, and clubs may be limited by the need for equipment purchases and extra training sessions in addition to usual practice and competition. A more practical, cost-effective solution would be to implement a neuromuscular training program that requires no additional equipment and can be easily integrated into warm-up routines.

The Y-Balance Test (YBT), a validated derivation of the Star Excursion Balance Test, is a functional screening tool that can be reliably administered for a variety of purposes: to assess lower extremity stability, monitor rehabilitation progress, understand deficits following injury, and identify athletes at high risk for lower extremity injury (Gribble et al 2012) . The YBT utilizes the anterior, posteromedial, and posterolateral components of the Star Excursion Balance Test to evaluate neuromuscular characteristics such as lower extremity coordination, balance, flexibility, and strength. Plisky et al. (Plisky et al. 2009), found that poor performance on the YBT is associated with an elevated risk for noncontact lower extremity injury; therefore, it could be a useful tool to assess the effectiveness of a prevention-training program for reducing the risk of such injuries. The aim of this study was to determine whether an 8-week neuromuscular training program focused on core stability, plyometric, and bodyweight strengthening exercises could improve postural control in female basketball players as assessed with the YBT.

Methods

Participants

Participants were recruited from two female basketball teams of the Italian national league. Before entering the study, the participants were fully informed about the study aims and procedures, and written informed consent was obtained before testing. Participants were free to withdraw from the study without penalty at any time. The study protocol was approved by the Institutional Ethics Review Committee of the Università degli Studi di Milano in accordance with current national and international laws and regulations governing the use of human subjects (Declaration of Helsinki II). Inclusion criteria were age ≥ 18 years, playing at the national level, and practice 4 times a week for ≥ 2 hours. Exclusion criteria were a history of lower extremity injury or surgery in the 6 months prior to testing. Participants were excluded from analysis if they did not attend 90% of the training sessions. A sports medicine specialist and a certified strength and conditioning coach screened the participants for eligibility. None were known to have had prior exposure to the YBT or specific dynamic balance training, which might have interfered with the validity of the testing protocol. Twenty-nine of the 32 players screened were deemed eligible and randomized by the researcher (R.B.) in a 1:1 ratio to receive either neuromuscular training (experimental group; n = 14; age 20 ± 2 years; body mass 62 ± 8 kg; height 1.72 ± 0.07 cm; weekly training volume 7 ± 1 hours) or standard tactical-technical training (control group; n = 15; age 20 ± 1 years; body mass 63 ± 7 kg; height 1.70 ± 0.07 cm; weekly training volume 7 ± 1 hours). One participant in the control group dropped out because she did not attend 90% of the training sessions and was not included in the final analysis (Figure 1). Data on medical history, age, height, body mass, training characteristics, injury history, team basketball experience, and performance level were collected at baseline. Height was measured to the nearest 0.1 cm with a portable stadiometer; body mass was measured to the nearest 0.1 kg using a portable scale; limb length from the anterior superior iliac spine to the medial malleolus on each limb was measured to the nearest 0.1 cm in the supine position. Comparison of the demographic characteristics of the two groups showed no significant differences in age, body height or mass. The participants were asked not to engage in other forms of physical activity other than their normal routines and to maintain their usual diet for the duration of the study.

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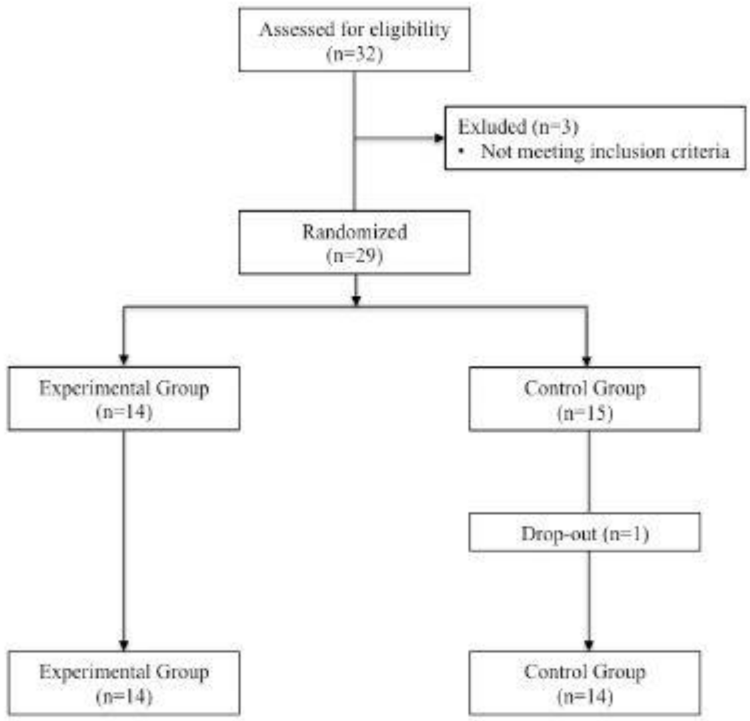

Figure 3. 1- Table of eligibility

Neuromuscular training

The neuromuscular training sessions took place twice a week (Tuesdays and Wednesdays) for 8 weeks (16 sessions) during the warm-up immediately before regular basketball training. The sessions were conducted by a certified strength and conditioning coach who gave verbal and visual feedback on exercise technique. Each 30-minute session comprised circuit training consisting of 10 different exercises with 3 minutes rest between circuits. The exercises were progressed through three different phases (Table 1) using periodization methods. Initially, low volume high-intensity exercises were performed until the technique was mastered. The volume was then increased when the exercise was executed correctly according to the coach's judgment. The exercises were progressed from a stable to an unstable position to increase demands on lower extremity strength and core stability. The training program did not include exercises that emulated the YBT. No acute injuries occurred during the training sessions.

BODYWEIGHT NEUROMUSCOLAR TRAINING PROGRAM

Phase 1 (1-3 week)	Phase 2 (4-6 week)	Phase 3 (7-8 week)
1. Plank on elbows (30 sec)	1. Plank on elbows, alternate 1 leg up (30 sec)	1. Plank on hand, alternate 1 leg up (30 sec)
2. Side Bridge (30 sec)	2. Side Bridge, with open the leg up (30 sec)	2. Side Bridge and over hip and arm abduction (30 sec)
3. One leg hip lift (10 rep)	3. One leg hip lift, over a basket ball (10 rep)	3. One leg hip lift, on step (10 rep)
4. Split squat (10 rep)	4. Bulgarian split squat (10 rep)	4. Bulgarian split squat and jump (10 rep)
5. Front lunges (10 rep)	5. Walking lunges (10 rep)	5. Walking lunges and crossover (10 rep)
6. Calf 2 leg on step (10 rep)	6. Calf 1 leg, on step (10 rep)	6. Calf 1 leg repeated, on step (10 rep)
7. Abdominal crunches (20 rep)	7. Abdominal sit-up and twist (20 rep)	7. Bicycle abdominals (20 rep)
8. Lateral jump and hold (10 rep)	8. Lateral jump, continuous movements (10 rep)	8. Lateral hop and hold (10 rep)
9. Back hypertension on ground (10 rep)	9. Superman, static (30 sec)	9. Hyperextension, on bench (10 rep)
10. Tuck jump and soft landing (10 rep)	10. Tuck jump, repeated (10 rep)	10. Jump over the cone (10 rep)

Table 3.1: - Bodyweight neuromuscolar training program

Testing Procedures

Postural control assessment with the YBT was performed at baseline (before [T0]) and at the end of the 8-week study period (T8). Test-retest reliability and measurement error of the YBT were analyzed by repeating the test at two sessions 1 week apart and then comparing the scores using interclass correlation coefficient (ICC). The YBT was carried out using a standardized testing protocol that has been shown to be reliable (Plisky et al. 2006; McKeon et al 2008).

The participants were fully familiarized with the testing procedures the first time that they came to the laboratory. After watching a standard video demonstration, they were provided initial YBT instruction and six practice trials with six reaches in each direction. This was done to minimize the potential for learning effect (Plisky et al 2009) . Before testing, the participants performed 10 minutes of standardized warm-up with 5 minutes of submaximal running followed by a dynamic stretch routine consisting of functional exercises: front to back leg swing, side to side leg swing, lateral lunge (squat to flow), and sumo squat to stand. Stretching was not allowed since it might have introduced confounding factors due to stretching one side more vigorously than the other.

Assessment with the YBT was performed using a Y-Balance Test kit comprising a stance platform to which three pieces of PVC pipe are attached in the anterior (AA), posteromedial (PM), and posterolateral (PL) reach directions. The posterior pipes were positioned 135 degrees from the anterior pipe with 34 degrees between them. Each pipe was marked in 5-millimeter increments for measurement. The YBT was performed barefoot with the distal aspect of the great toe centered at the junction of the Y. The participants had to reach with the opposite leg in the anterior, posteromedial, and posterolateral directions (Figure 3.2) and push a target (reach indicator) along the pipe that standardized the reach distance; the target remained over the tape measure after completion of the test. The testing order was three trials standing on the right foot while reaching with the left foot in the anterior direction followed by three trials standing on the left foot and reaching with the right foot in the anterior direction. The procedure was repeated for the posteromedial and then the posterolateral reach directions. During the trials, the reach foot was not allowed to touch the floor or gain balance from the reach indicator or support pipe. If the participant was unable to perform the test according to the above criteria in six attempts, she failed that direction, no data were collected, and another trial was attempted. Reach distance was measured from the most distal aspect of the toes of the stance foot to the most distal aspect of the reach foot in the anterior, posteromedial, and posterolateral directions. The YBT scores were analyzed using the average of the last three trials for each reach direction for each lower extremity, as well as the average of the total of reach directions (composite score). The YBT composite score was calculated according to Plisky et al. [19] by dividing the sum of the maximum reach distance in the anterior, posteromedial, and posterolateral directions by 3 times the limb length (LL) of the participant, then multiplied by 100 [(AA+PM+PL)/(LL*3)]*100. The maximum value measured for each excursion direction was also analyzed, as well as the summed composite score of the maximums for each lower extremity. In order to control for the effect of limb length between participants, the YBT values were normalized to percent of average anatomical limb length (average of right and left side).

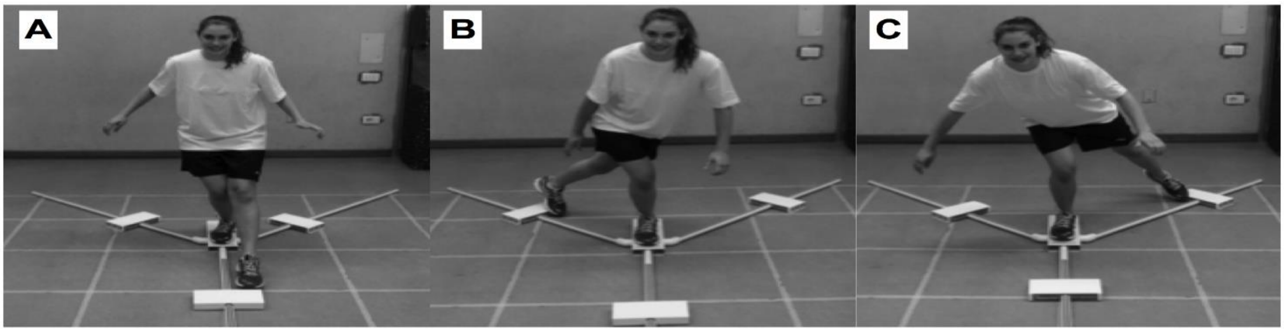

Figure 3.2 - A= Anterior direction, B= Posteromedial direction, C=Posterolateral direction

Data analysis

Descriptive statistics (mean ± SD) for the outcome measure were calculated. Data normality was checked with the D'Agostino Pearson test. Interclass correlation (ICC) was used to establish inter-session repeatability of all measures, where α or r < 0.50 was classified as weak, from 0.50 to 0.79 as moderate, and ≥ 0.80 as strong. To determine the effect of neuromuscular training, two-way analysis of variance (ANOVA) with Tukey's multiple comparisons test was applied. The level of significance was set at $P < 0.05$. Statistical analysis was performed using GraphPad Prism version 6.00 for Mac OSX (GraphPad Software, San Diego, CA, USA). Cohen's effect sizes (ES) (Cohen 1988) were calculated to assess the magnitude of effects between pre- and post-training in the experimental group and between the two groups. Values < 0.2, < 0.6, < 1.2 and > 2.0 were interpreted as trivial, small, moderate, large, and very large, respectively [Betterham & Hopkins 2006)].

Results

At the end of the training program, the composite YBT score for the right limb improved from 88.6 to 94.0% (+5.4%, $P = 0.0004$) and from 89.2 to 95.5% (+5.8%, $P = 0.0011$) for the left limb in the experimental group. The ICC (1,1) of the anterior, posteromedial, posterolateral, and composite YBT scores were 0.91, 0.88, 0.83, and 0.90, respectively, for the right limb and 0.88, 0.90, 0.82, and 0.89, respectively, for the left limb. Figures 3 and 4 show that, as compared with the control group, the experimental group demonstrated significant improvement on all measures at T8 versus T0 ($P = 0.0487$, ES = 0.9 for posteromedial direction, Figure 3B; $P = 0.0156$, ES = 1.0 for posterolateral direction, Figure 3C), and on composite YBT scores for the right lower limb ($P = 0.0004$, ES = 2.1, Figure 3D) and for the left lower limb ($P = 0.0383$, ES = 1.0 for posteromedial direction, Figure 4B; $P = 0.0109$, ES = 1.1 for posterolateral direction, Figure 4C) and on composite YBT scores ($P = 0.0011$, ES = 2.0, Figure 3D). Significant differences between the two groups at T8 were noted in posteromedial ($P = 0.0045$; ES = 2.3) and composite YTB scores ($P < 0.0001$, ES = 2.6) for the right lower limb (Figure 3) and in posteromedial ($P = 0.0034$, ES = 1.9) and composite YTB scores ($P < 0.0001$, ES = 2.5) for the left lower limb (Figure 4). No significant differences in the anterior direction were found.

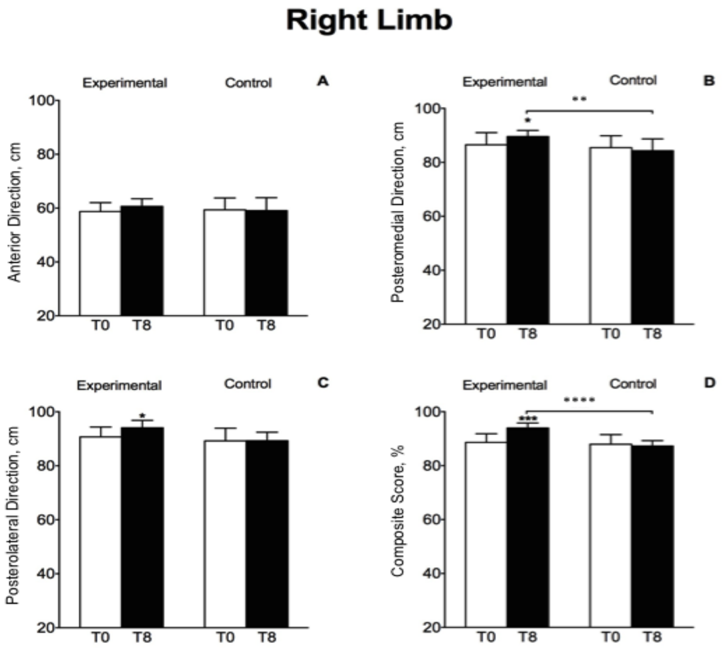

Figure 3.3 - YBT-LQ right limb: A= Anterior direction, B= Posteromedial direction, C=Posterolateral direction, D =Composite score %

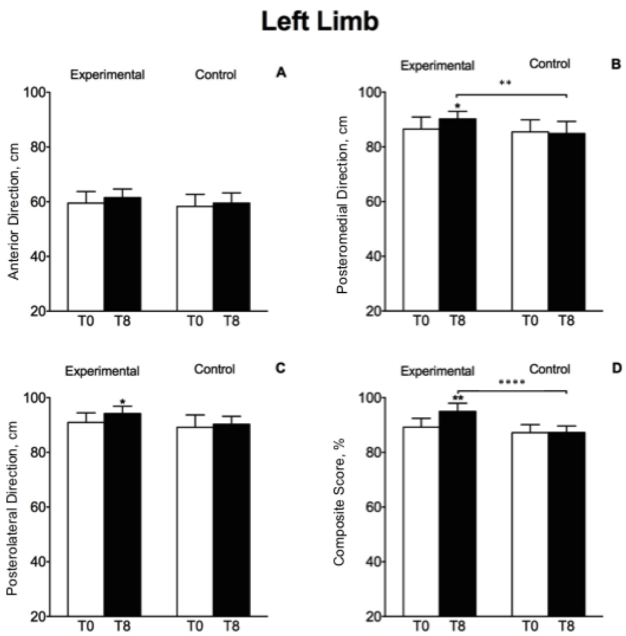

Figure 3.4 -YBT-LQ left limb: A= Anterior direction, B= Posteromedial direction, C=Posterolateral direction, D =Composite score %

Discussion

The experimental and the control group demonstrated similar baseline YBT performance for all variables measured. Comparison of pre- and post-intervention posteromedial and composite YBT scores of both lower limbs showed significant improvement in the experimental group as compared with the control group. Improvement in the YBT composite score in the experimental group reflected increases in posterolateral and posteromedial reach at T8 versus T0. No significant differences in the anterior direction were found.

Lower limb injury prevention

Neuromuscular training and core stability exercises. Neuromuscular training can be integrated with core stability exercises in ankle or knee injury prevention programs [Zazulack et al 2007; Mc Keon et al.2008]. The exercises selected for this neuromuscular training program were based on findings from injury prevention research on lower extremity strength and core stability [Hewett et al 2005; Hewett et al. 2006; Mandelbaum et al. 2005; Zazulack et al. 2007; McKeon et al.2008; Filipa et al. 2010) . Core stability is defined as dynamic trunk control that allows for the production, transfer, and control of force and motion to distal segments of the kinetic chain (Kibler et al 2006) . Improvements in the posterolateral and posteromedial direction are more likely the result of enhanced neuromuscular control and dynamic balance and less related to lower extremity strength (Thorpe et al. 2008). Inadequate neuromuscular control of the trunk appears to influence the dynamic stability of the lower extremity during high-speed athletic maneuvers (Gribble et al. 2012).

Plyometric exercises and risk of ACL injury. We included bodyweight plyometric exercises in our neuromuscular training program because they train the muscles, connective tissue, and nervous system to effectively carry out the stretch-shortening cycle. Also, focused attention to correct technique and body mechanics may better prepare athletes for multidirectional sport activities, address neuromuscular imbalances, and reduce the risk of serious ligament injuries in female athletes (Lloyd et al.2001). In their studies on the prevention of anterior cruciate ligament (ACL) injury in female athletes, Hewett et al. (1999) , Huston et al. (2000) , Myklebust et al. (2003) , and Mandelbaum et al. (2005), incorporated into their intervention designs high-intensity jumping plyometric movements that progressed beyond footwork and agility. All four reported a reduction in the risk of ACL injury. In contrast, no reduction in ACL injury risk was reported by Heidt et al.(2000), and Soderman et al.(2000), who did not include plyometric exercises in their prevention programs. In their prospective study involving 1263 male and female athletes from various sports, Hewett et al.(1999), investigated the effects of a 6-week neuromuscular training program consisting of stretching, plyometric exercises, and weight training with an emphasis on correct alignment and technique. The authors noted that the incidence of serious knee injuries was 2.4 to 3.6 times higher in the untrained group than in the trained group. Among the untrained female athletes, 5 sustained a noncontact ACL injury, whereas none of the trained females did, and 1 male athlete sustained an ACL injury (relative injury incidence, 0.26, 0, and 0.05, respectively).

Huston et al. (2000), carried out an 8-year prevention program involving two division 1 female basketball teams. The program was geared at changing player technique, stressing knee flexion on landing, using accelerated rounded turns, and decelerating with a multistep stop. The authors noted an 89% reduction in the rate of current ACL injuries in the intervention group. Finally, a 2-year cohort study was conducted by Mandelbaum et al. (2000), to determine whether a neuromuscular and proprioceptive performance program was effective in decreasing the incidence of ACL injury in a selected population of competitive female youth soccer players. There was an 88% decrease in ACL injuries in the intervention group as compared to the control group during the 2000 season and a 74% reduction in ACL tears in the intervention group as compared with the age- and skills-matched controls during the 2001 season.

Practical implications. A further aim of our neuromuscular training program was to enhance performance. In their meta-analysis of neuromuscular interventions, Hewett et al. (2006), reported that athletes might not be sufficiently motivated to participate in a neuromuscular training program. In fact, prevention training without performance-enhancing effects in female athletes may have a compliance rate as low as 28%, whereas compliance with programs that combine performance enhancement and injury prevention may range from 80 to 90%. Finally, recognizing that training time is limited for nonprofessional athletes and that special equipment purchases (e.g., Swiss balls, medicine balls, and unstable bases) may be necessary, we devised this training program based on bodyweight exercises that can be easily integrated into warm-up routines. Moreover, we assessed our athletes with the YBT because it is a validated, reliable derivation of the Star Excursion Balance Test, a widely used tool to screen individuals for limitations in dynamic balance (Plisky et al.2009). Poor performance on the YBT has been associated with an elevated risk of noncontact lower extremity injury (Plisky et al.2009). . Plisky et al. (2009), found that girls with a composite reach distance of less than 94.0% of their limb length were more than 6 times more likely to sustain a lower extremity injury. Although we did not investigate the effects of neuromuscular training on lower limb injury, the post-intervention improvements in postural stability suggest that performance on the YBT may serve as a corollary outcome measure for assessing athletes at risk for lower limb injury. One limitation of our study is that we did not evaluate lower limb strength. However, Lee et al. (Lee et al

2014), found a positive correlation between lower limb strength and reach distance in all three directions of the YBT in adult women. A strong relationship was also noted between knee flexor strength and performance in all three directions. Since a greater range of motion for hip flexion is required for reaching a greater distance, this may have placed an increased demand on hip extensor strength to maintain postural control. Furthermore, because reaching in the posteromedial direction requires lateral stabilization of the pelvis, hip abductor strength correlated positively with the posteromedial reach distance.

Conclusions

Posteromedial, posterolateral, and composite YBT scores for both lower limbs significantly improved in the experimental group after neuromuscular training with bodyweight core stability and plyometric exercises. Incorporating neuromuscular training into the regular basketball warm-up routine may be an effective way to increase joint awareness and improve posture control. The YBT is a reliable tool to assess posture control and lower limb stability in young female basketball players and possibly identify those at potential risk for lower extremity injury.

Chapter 4

Injury Prevention in Sports

Intrinsic Injury-Prevention Strategies

In recent years, more research has focused on intrinsic injury-prevention strategies using rigorous methods as they apply to many of the Olympic sports. The intrinsic injury-prevention strategies that will be evaluated are strength training, stretching, balance training, educational video interventions, and multiple types of interventions.

Strength Training

Several studies have evaluated the use of strength training in the prevention of hamstring strains. Askling et al. (2003) used a randomized, controlled trial in soccer players to evaluate a preseason hamstring-strengthening program and noted a 70% decrease in hamstring injuries. Another study of soccer players (Gabbe et al. 2006) found no effect of hamstring-strengthening interventions in a welldesigned randomized, controlled trial, although the results of this study likely were affected by poor participation in the intervention sessions. Although both trials evaluating strength training used a randomized, controlled trial design, they were limited by reporting numbers of injuries rather than injury rates that account for each participant's athlete exposure time. Although strength conditioning is a biologically plausible intervention for the prevention of strains of specific muscle groups, additional well-designed studies of this intervention are needed.

Stretching

Many athletes perform stretching exercises as part of their pre-exercise preparation for sport participation. Several randomized, controlled trials have evaluated the effect of static stretching in military recruits and found no effect on risk of injury (Pope et al. 1998; Pope et al. 2000). Other studies using a nonrandomized, controlled clinical trial design in football players (Cross & Worrell 1999) and military recruits (Hartig & Henderson 1999) found a decreased risk of injury, but these studies may have been affected by poor study methods, including non randomization, lack of a control group (Cross & Worrell 1999), and no adjustment for confounders or accounting for athlete-exposure time (Cross & Worrell 1999; Hartig & Henderson 1999). A systematic review pooling results from five controlled studies found no effect of stretching on sports injury (Thacker et al. 2004). In light of these findings, routine stretching exercises before initiation of sport activities are not a proven, effective method for reducing injury rates.

Balance Training Balance

Training programs have been hypothesized to prevent sports injuries, especially those to the lower extremity and ankle. Studies have evaluated a variety of balance training programs during the sports season among athletes who participate in volleyball, handball, soccer, and basketball. The balance training programs have consisted of various components, including the use of a balance board or ankle disk, balance exercises such as maintaining a single-leg stance on a flat surface with eyes open and closed, and performing sports activities on one leg. The majority of studies noted a decreased risk of injuries overall and a decreased risk of ankle sprains (Wedderkopp et al. 1999, 2003; Verhagen et al. 2004; Emery et al. 2005; McGuine & Keene, 2006). Injuries were noted to be decreased by 50% to 85% with balance training (Verhagen et al. 2004; Emery et al. 2005; McGuine & Keene 2006). In contrast, Soderman et al. (2000) noted no effect of balance training on injuries among soccer players, but reported an increased risk of serious soccer injuries resulting in 30 days of participation lost among the intervention group. Verhagen et al. (2004) found a decreased risk of acute ankle injuries among volleyball players but an increased risk of overuse knee injuries associated with balance board training among athletes with a prior knee injury. The majority of these studies used rigorous methods for their study design and analysis. In light of these positive findings, balance training programs can be recommended as an effective prevention strategy for sports injuries.

Feedback and educational video

Several studies have used video presentations to sport participants with the goal of decreasing the rate of injury. Two studies have focused on injury prevention for recreational skiers and ski resort employees. Jorgensen et al. (1998) evaluated the effect of an educational video on how to avoid injuries among skiers being transported by bus to ski resorts. Skiers were randomly assigned by busload to view or not to view the video. Skiing injury rates were decreased by 30% for those riding on the buses showing videos as compared with those on buses without the educational video. Another educational video intervention to prevent injury involved specific types of athletes viewing a video of an athlete at the time of an injury event. Following the viewing of the video, the athletes were instructed on using guided discovery to increase their awareness of injuries and their mechanism. An anterior cruciate ligament (ACL) injury-prevention program was developed using this guided discovery method for ski resort employees around the United States (Ettlinger et al. 1995). These investigators reported a 62% decreased risk of ACL injuries among ski resort employees who participated in the program as compared with those who did not participate, although these results must be viewed with caution because of the nonrandomized design, with the potential for confounding and the lack of adjustment for exposure time for each subject. Arnason et al. (2005) used a similar type of video training in a randomized, controlled trial for adult male soccer players and found no effect on injury rates.

Videoed drop jump tasks have been proved to be reliable means to predict ACL injury risk in women and detect some of these pathomechanical postures, including excessive hip adduction, femoral internal rotation, tibial external rotation, and foot pronation postures (Hewett, et al.2005). Another advantage of the videoed drop jump task is that video feedback of landing technique in conjunction with verbal feedback to participants has a compounding beneficial effect on landing technique and reduction in larger peak vertical ground reaction force. (Onate et al.2005).

Feedback is a fundamental tool for learning and performing of motor skills and is seen as a quick and simple alternative to more time-consuming and labour intensive training programmes previously investigated. Early studies assessed the effect of feedback in its most simple verbal form, which is often used to supplement training programmes. Papavessis and McNair (1999) compared the effect of specific verbal instruction to one group of participants to ‘land on their toes and bend their knees’ against another group who were instructed to use sensory feedback from previous jumps to ‘minimise the stress of landing’ during a bilateral drop landing task. The results showed that the verbal feedback group reduced vertical ground reaction force.
Same results were also noted in several further studies where simple verbal instructions were given (Cowling et al., 2003; McNair et al., 2000; Mizner et al., 2008). In addition, Cowling et al. (2003) noted that a simple instruction to ‘bend your knees’ during a unilateral landing brought about significant increases in knee flexion angles

Greater improvements may be seen using feedback criteria based on identification of high-risk movement patterns such as the Landing Error Scoring System (LESS) (Padua et al., 2009).

Multiple Interventions

Although the studies discussed above have used a single intervention approach to preventing injuries, many studies have used multiple interventions that combine two or more sports injury–prevention activities in a single trial. Several rigorously designed, randomized, controlled studies compared warm-up activities and balance training on a wobble board to the usual training in youth handball (Olsen et al. 2005) and basketball (Emery et al. 2007) players. The handball players also had strength training. These studies found a 30% to 50% decreased risk of acute injuries among the intervention group compared to the control group. Van Mechelen et al. (1993) and Ekstrand et al. (1983) also performed randomized, controlled studies to evaluate warmup, cool-down, and either stretching (van Mechelen et al. 1993) or ankle taping (Ekstrand et al. 1983) among soccer (Ekstrand et al. 1983) and recreational runners (Van Mechelen et al. 1993). van Mechelen et al. (1993) noted no effect of the intervention, while Ekstrand et al. (1983) found a 75% decreased risk of injuries. Another randomized, controlled trial (Heidt et al. 2000) in female youth soccer players used the Frappier Acceleration Training Program, which incorporates cardiovascular conditioning, plyometrics, and strength and flexibility training into the intervention group. Those in the intervention group had a decreased risk of injury as compared with the control group. Numerous nonrandomized, controlled trials using multiple interventions have been performed, with many showing a decrease in injuries in the intervention group. Several of the nonrandomized trials have focused on jumping and landing skills as well as proprioceptive training (Caraffa et al. 1996; Hewett et al. 1999; Mandelbaum et al. 2005; Petersen et al. 2005; Scase et al. 2006). These studies evaluated soccer, basketball, and volleyball players and noted a 28% decrease in any injuries (Scase et al. 2006) and a 70% to 80% decrease in knee injuries (Caraffa et al. 1996; Hewett et al. 1999; Mandelbaum et al. 2005). A study of female handball players focusing on jumping and landing skills along with use of a balance training component found no effect on the risk of injury (Petersen et al. 2005). Other studies of multiple interventions have evaluated combinations of warm-up and cool-down exercises as well as strengthening and stretching exercises among soccer (Junge et al. 2002) and rugby players (Brooks et al. 2006) and long distance runners (Jakobsen et al. 1994). All have noted a decreased risk of injury with these interventions. Findings from these nonrandomized trials should be viewed with caution because of the potential for selection bias of the study subjects and the possibility of confounding as an explanation for the protective effect. In conclusion, the use of multiple interventions to prevent sports injuries appears promising and should be investigated further. One limitation of intervention trials that use multiple interventions in a trial group is that it is difficult to characterize the contribution of each aspect of the intervention to the decrease in injury. Future studies should consider the possibility of comparing several intervention groups to the control arm to separate the effects of each type of intervention.

Extrinsic Injury-Prevention Strategies

Some of the first sports injury–prevention strategies have focused on extrinsic strategies, mainly protective equipment. The extrinsic injury prevention strategies that will be evaluated are mouth guards, face shields, helmets, bracing and orthosis use, insoles and footwear, breakaway bases, and sporting rules. Mouth Guards the effectiveness of mouth guards has been studied for a number of years among athletes in several different sports, including rugby, basketball, American football, and hockey.

Mouth guards, regardless of the type of device, have been consistently shown to decrease the risk of orofacial injuries such as dental, mouth, and jaw injuries. One study (Finch et al. 2005) using rigorous methods, including a randomized, controlled design with an intention-totreat analysis documented a 44% decreased risk of head and orofacial injuries among users of mouth guards. A meta-analysis (Knapik et al. 2007) of 13 studies evaluating the effects of mouth guards documented a pooled effect of an 86% increased risk of orofacial injuries among nonusers of mouth guards. Mouth guards in these studies were used by athletes participating in American football, basketball, and Australian football. In addition to the prevention of orofacial injuries, some studies (Labella et al. 2002; Barbic et al. 2005; Mihalik et al. 2007) have evaluated the association between mouthguard use and the risk of concussion and neuropsychological symptoms following concussion. None of these studies found a protective effect of mouth guards on the risk of concussion. Face Shields Face shields are another extrinsic type of injury-prevention strategy that has been evaluated for use in sports with a high risk for facial injury, such as ice hockey and baseball. Although no randomized, controlled trials have evaluated face shields, several cohort studies (Benson et al. 1999; Stuart et al. 2002;

Bracing and Orthosis Use

Another extrinsic injury-prevention measure that has been evaluated is the use of joint bracing or support. Several individual studies along with a meta-analysis have evaluated the effects of orthoses and taping on the risk of ankle sprains. Using a randomized,controlled trial, Surve et al. (1994) found a decreased risk of recurrent ankle sprain among soccer players using a sport-stirrup orthosis. A meta-analysis (Handoll et al. 2007) of five studies of ankle orthoses among basketball and soccer athletes noted an overall 47% decreased risk of ankle sprain.

A study of high-school athletes by Yang et al. (2005) evaluated discretionary protective equipment and found a 56% decreased risk of knee injuries with the use of knee pads and a 61% increased risk of knee injuries with the use of a knee brace, although some of these results may be confounded by reasons for use of this equipment.

In addition to lower-extremity bracing, some studies of snowboarders have evaluated the effectiveness of wrist protectors on the risk of wrist and upper-extremity injury. Two randomized, controlled trials (Machold et al. 2002; Ronning et al. 2001) and one case–control study (Hagel et al. 2005a) have shown a 72% to 87% decreased risk of wrist injuries, including wrist fractures and sprains, among snowboarders who used wrist protectors.

The effect of wrist protectors on the risk of shoulder or upper-arm injuries has also been evaluated. Machold et al. (2002) noted a nonsignificant decreased risk of shoulder injuries among the group who used wrist protectors, whereas Hagel et al. (2005a) noted a nonsignificant increased risk of injuries between the elbow and the shoulder in a case–control study.

Although wrist protectors appear to decrease wrist injuries, additional studies are needed to determine effects on the risk of other upper-extremity injuries before wrist protectors can be recommended for injury prevention among snowboarders.

Insoles and Footwear

Orthotics and shoe insoles have been used as potential prevention measures for overuse injuries and stress fractures.

The majority of studies of orthotics and insoles have been performed in military populations, with conflicting results. Investigators (Gardner et al. 1988; Withnall et al.2006) have evaluated polymer and polyurethane foam insoles in military populations and noted no effect on lower-extremity stress fractures or any type of lower-extremity injury. Milgrom et al. (1985) noted a 50% decreased risk of stress fractures with the use of orthotics. Schwellnus et al. (1990) evaluated the effect of neoprene insoles using a randomized, controlled trial and found a 34% decreased risk of overuse injuries among those in the insole group. Several studies (Andrish et al. 1974; Bensel & Kaplan 1986; Schwellnus et al.) have evaluated the effect of insoles on the development of shin splints, with only one of the studies (Schwellnus et al. 1990) reporting a 59% decrease in shin splints. None of the studies of orthotics and insoles have evaluated their effectiveness in athletes participating in sports with a high risk of lower-extremity injuries and stress fractures such as basketball, soccer, volleyball, and handball. In addition to evaluations of orthotics and insoles, only one study has evaluated the type of shoe as a sports injury–prevention strategy. Barrett et al. (1993) evaluated high-top versus low-top shoes for the prevention of ankle sprains in basketball players and noted no statistically significant effect, although this study was limited by relatively few ankle sprains among the players.

Based on: Schiff M.and O'Halloran R.

Chapter: Injury prevention in sports

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Neuromuscular warm-up strategies for preventing lower limb injuries

Recently, researchers and sports medicine practitioners have developed and investigated multifactorial neuromuscular training strategies targeting injury prevention for a variety of sports and athletic levels.

Neuromuscular training programmes are hypothesized to improve joint position sense, enhance joint stability and develop protective joint reflexes, ultimately preventing lower limb injuries. Hübscher et al.(2010) recently completed a high quality systematic review on neuromuscular training programmes for sports injury prevention.

A meta-analysis indicated that multi-intervention programmes may reduce lower limb, acute knee and ankle injuries and that balance programmes may reduce ankle injuries (Hübscher et al. (2010) . However, the practicality of these findings for many individuals, teams and clubs may be limited due to the need for equipment purchases (for example, balance boards) and the requirement of additional training sessions to normal practice and competition. In these cases, a more practical solution would be to encompass neuromuscular training programmes which do not require additional equipment and which can be incorporated into warm-up or current routines. A number of neuromuscular warm-up strategies which fit these criteria have been proposed, evaluated and published in the literature. Just two of these programmes were included by the Hübscher et al. (2010) a systematic review.

An neuromuscular warm-up strategies which can be easily incorporated into warm-up or current routines and do not require the acquisition of additional equipment is needed to further guide recommendations for effective lower limb injury prevention.

Herman et al (2012) in a recently systematic review of the literature related with the purpose to evaluate the efficacy of functional neuromuscular warm-up strategies which do not require additional equipment in preventing lower limb injury in order to guide clinical and sporting practice and to identify the common elements of successful strategies in order to guide future research.

In this review we found a follows studies:

Table 4.1.Summary of details regarding each included study

Study	Design	Participants	Neuromuscular warm-up program	Control Group	Outcome
Mandelbaum *et al.* [26]	CCT	1,041 female soccer players, aged 14 to 18 years	Prevent Injury and Enhance Performance Programme: three basic warm-up exercises, five stretching exercises for the trunk and lower extremities, three strengthening exercises, five plyometric exercises and three soccer-specific agility drills. Performed before matches and training, 20 minutes, for two years	Normal warm-up strategy	ACL injuries
Pfeiffer *et al.* [27]	CCT	1,439 female soccer, basketball and volleyball players, aged 14 to 18 years	Knee Ligament Injury Prevention Programme: four progressive phases of jumping and landing forwards and backwards, two- and one-footed drills, plyometric and agility training. Performed either before or after training sessions twice a week, 20 minutes, for two consecutive seasons	Normal warm-up strategy	ACL injuries
Gilchrist *et al.* [28]	RCT	1,435 female football players, average age 19.9 years	Prevent Injury and Enhance Performance Program: Three basic warm-up exercises, five stretching exercises for the trunk and lower extremities, three strengthening exercises, five plyometric exercises and three soccer-specific agility drills. Before training, 20 minutes three times a week for 12 weeks	Normal warm-up strategy	Undefined knee and ACL injuries
Kiani *et al.* [29]	CCT	1,506 female football players, aged 13 to 19 years	The 'HarmoKnee' program: warm-up, muscle activation, balance, strength, core stability exercises. Performed twice a week preseason (three months), once a week during in-season training session (six months), total duration 20 to 25 minutes	Normal warm-up strategy	All new knee injuries
LaBella *et al.* [30]	RCT	1,558 female football and basketball players, average age 16 years	Knee Injury Prevention Program: combining progressive strengthening, plyometric, balance and agility exercises. In season for one year. Total duration 20 minutes before team practices, an abbreviated version with dynamic motion exercises only before games	Normal warm-up strategy	Gradual-onset lower extremity injuries, acute-onset non-contact lower extremity injuries, non-contact knee, ACL and ankle sprains
Soligard *et al.* [31]	RCT	1,982 female football players, aged 13 to 17 years	The '11+': 10 exercises including slow running, active stretching, controlled contact, exercises for strength, balance, jumping and soccer-specific agility drills. Before training, 20 minutes, only running exercises before match, for eight months	Normal warm-up strategy	Overall and overuse lower limb injuries, groin, posterior and anterior thigh injuries, undefined knee, MTSS and undefined ankle injuries
Steffen *et al.* [32]	RCT	2,020 female football players, aged 13 to 17 years	The '11': 10 exercises for core stability, balance, dynamic stabilization and eccentric hamstring strength. Two months preseason, six months in-season before training, 20 minutes for 15 consecutive training sessions then once a week thereafter	Normal warm-up strategy	Overall lower limb injuries, groin and thigh injuries, undefined knee and ACL injuries, and undefined ankle injuries
Coppack *et al.* [33]	RCT	1,502 male and female army recruits, aged 17 to 25 years	Anterior Knee Pain Prevention Training Programme: warm-up consisted of eight exercises closed chain strengthening exercises, 10 to 14 repetitions each; warm-down involved four stretching exercises, three repetitions. Performed at each training session (mean = seven per week), 15 minutes, for 14 weeks	Normal warm-up strategy (running, stretching, strengthening)	AKP
Brushøj *et al.* [34]	RCT	1,020 female and male army recruits aged 19 to 26 years	Prevention Training Programme: Five exercises for strengthening, balance, stretching performed in three sets of five to 25 repetitions. Before military training, 15 minutes, three times a week for 12 weeks	Strategy for the upper body	Overall and overuse lower limb injuries, AKP, patella tendinopathy, ITBFS, MTSS, ankle sprain and Achilles injuries.

ACL, anterior cruciate ligament; AKP, anterior knee pain; CCT, controlled clinical trial; ITBFS, iliotibial band friction syndrome; MTSS, medial tibial stress syndrome; RCT, randomized controlled trial.

Detailed of each studies are summarized in Table 4 including study design, participants, neuromuscular warm-up strategy evaluated, control intervention, and outcomes evaluated

In this review two studies (Coppacket al. 2011, Brushøj et al 2008) investigated male and female participants, while the remaining seven investigated females only (Mandelbaum et al 2005, Steffen 2008).

The age range of participants was 13 to 26 years. Five studies evaluated amateur football players (Mandelbaum et al.2005, Gilchrist et al 2008, Soligard et al, 2008, LaBella et al.2011, Kiani et al 2010), two studies evaluated army recruits (Coppack et al. 2011, Brushøj et al 2008 , one study evaluated amateur football and basketball players (LaBella 2010) and one study evaluated amateur football, basketball and volleyball players (Pfeiffer et al. 2006). Three studies evaluated primarily ACL injury (Mandelbaum et al.2005, Gilchrist et al 2008), two studies assessed all lower extremity injury risk which included the foot, ankle, leg, knee, thigh, groin and hip (Soligard et al. 2008, Steffen et al 2008), one study assessed lower extremity injuries which included knee and ankle (LaBella et al 2011) , one study evaluated injuries to the knee including collateral ligament, ACL, meniscal and patella injuries (Kiani A et al 2010) one study measured general overuse injuries (Brushøj et al 2010) and one specifically anterior knee pain (AKP). (Coppack et al 2011)

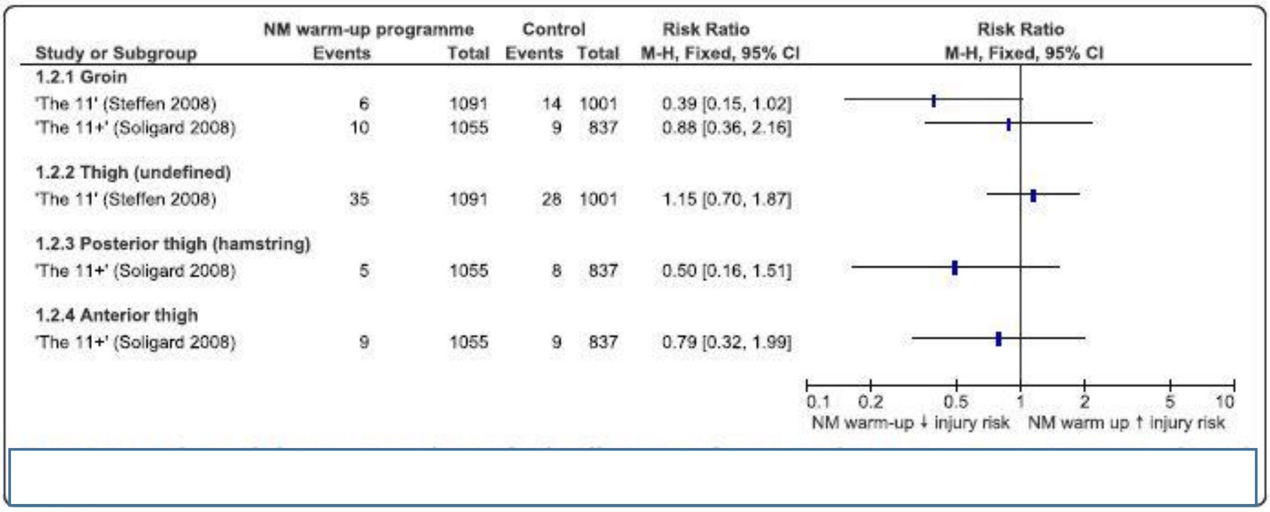


Figure 4.1 - Forest plot graph demonstrating risk for effectiveness of neuromuscular warm-up strategies hip and thight injuries

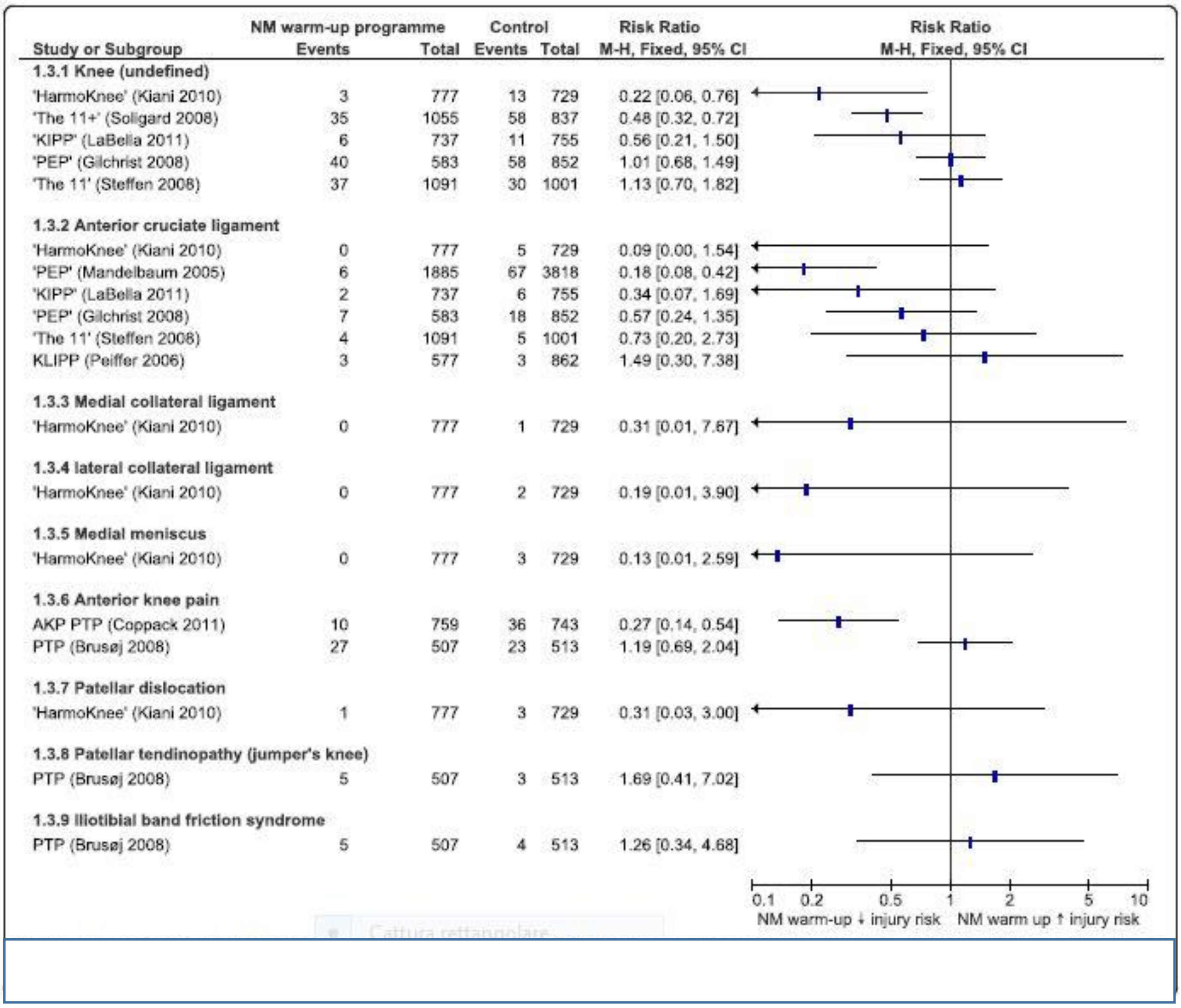


Figure 4.2 - Forest plot graph demonstrating risk for effectiveness of neuromuscular warm-up strategies knee thight injuries

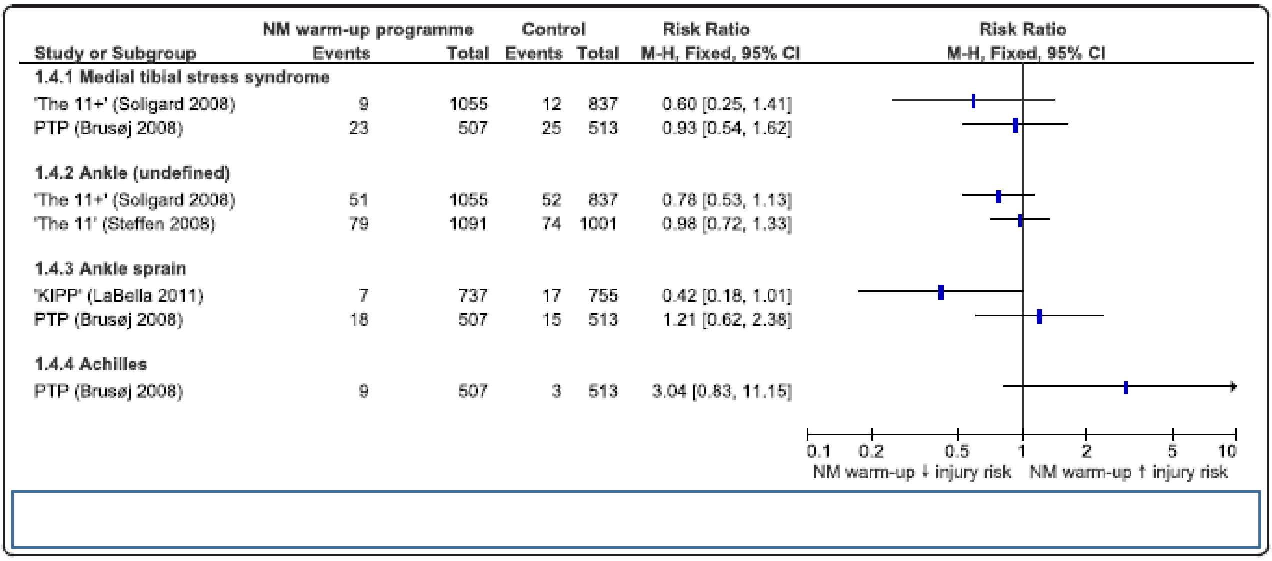


Figure 4.3-Forest plot graph demonstrating risk for effectiveness of neuromuscular warm-up strategies in preventing leg and knee injuries

Importantly, the highlights several areas that may account for significantly better injury prevention when incorporating neuromuscular warm-up strategies. These include: incorporation of stretching, strengthening and balance exercises, sports-specific agility drills and landing techniques; (Witvrouw et al 2004) completing the strategy for longer than three consecutive months; and (Thacker 2004) completing of the strategy at all training sessions. In addition to these programme specifics, further evaluation of the '11+'(Soligard et al, 2008) programme has highlighted the importance of compliance, with high compliance being linked significantly to reduced lower limb injury risk (Soligard et al. 2010).

Further studies need to determine whether 'The 11+'(Soligard et al, 2008), KIPP (LaBella et al.2011), 'HarmoKnee' (Kiani et al 2010), AKP PTP (Coppack et al.2011) and PEP (Mandelbaum et al.2005, Gilchrist et al 2008) programmes are also effective in men, other age groups, and other sports as our review incorporated mainly women and involved only football, basketball, volleyball and military training.

It is important to determine whether injury prevention programmes would also be effective if taught to older players who might possess more engrained poor motion patterns. In addition, healthcare professionals are encouraging middle-aged individuals to engage in sports and so research needs to include older individuals who are at a higher risk of sustaining an injury due to changed activity levels. It would also be beneficial to see if 'The 11+ (Soligard et al. 2008),'KIPP (La Bella et al.2011),'HarmoKnee' (Kiani 2010) , PEP (Mandelbaum et al.2005, Gilchrist et al 2008) strategy and AKP PTP (Coppack et al 2011) could be successfully combined to ultimately recommend a single injury prevention strategy.

Finally, we need to know more about the mechanisms of injury prevention of neuromuscular warm-up strategies in order to optimize their effectiveness.

In conclusions in the systematic review of Herman et al (2010) we identified five practical neuromuscular warm-up strategies which do not require additional equipment and which may effectively reduce the risk of lower limb injuries.

Specifically ‘The 11+’ reduced overall and overuse lower limb injuries and knee injuries in young amateur female football players, the ‘KIPP’ reduced non-contact overall and overuse lower limb injuries in young amateur female football and basketball players, the ‘HarmoKnee’ (Kianie et al.2010) programme reduced the risk of knee injuries, the ‘PEP’ strategy reduced the risk of non-contact ACL injury in young amateur female football players and the ‘AKPPTP’ reduced the risk of anterior knee pain in male and female military recruits.

Further research evaluating the effectiveness of these strategies in more varied populations, particularly men and older individuals is now needed. To provide the greatest potential for reduced lower limb injury rates, it is recommended that neuromuscular warm-up strategies incorporate stretching, strengthening and balance exercises, sports-specific agility drills and landing techniques, and are completed for a duration of longer than three consecutive months at all training sessions.

Identification of which neuromuscular warm-up strategy components are most beneficial and the mechanisms behind their effectiveness is needed to further reduce lower limb injury risks.

Study III

Prevention of lower limbs injuries in youth female basketball players: A pilot study

Introduction

Basketball is one of the most popular sports, and it is also one of the highest contributors to sport and recreation-related injuries.[1] As the sport grows, in terms of number of participants and intensity, so does the number of injuries. In 2006 FIBA (Fédération Internationale du Basketball Association) has estimated that 11% of the world´s population plays basketball.

The game of basketball is physically and mentally demanding. Basketball is characterized by intermittent bouts of high-intensity activity that occurs in the context of an endurance event. (Cumps et al 2007;Maughan et al 2010; Dougherty et al. 2006).

Though players rarely reach maximal running speeds when playing, they often overcome movement momentum to change direction or to accelerate/decelerate. Technically basketball is considered as non-contact sport, but there is usually a high level of physical interaction between players on opposing teams, suggesting that basketball evolves into a semi-contact sport. (Cumps et al 2007; Caine et al. 2010). The contact is responsible for 52.3% of the game-related injuries in male and 46.0% of injuries in female collegiate players. (Oblakovic-Babic 2005)

Definition of Injury:

There is a notable variability in used injury definitions among researchers. One of the broad injury definitions define injury as any muscular-skeletal complaint newly incurred due to competition and/or training that received medical attention regardless of absence from competition or training. (Junge et al.2008)

The advantage of this definition is possibility to assess full spectrum of injuries from mild contusions to fractures. Not only those which forces to lose a game, bearing in mind that athletes sometimes compete despite an injury. (Caine et al.2010) Although in practice, researchers more often apply the “time loss" definition. (Starkey, 2000) The types of injuries experienced by basketball players reflect the physical demands of the game.(McKay et al 2001)

An *acute (traumatic)* injury was defined as being a basketball accident with a sudden, direct cause/event responsible for the injury. In general, sprains (injuries to ligaments) are the most common type of acute injury. In college basketball sprains were experienced 37.1%, and in professional basketball sprains often accounted for about 27.8%. Other common injuries are contusions and strains (injuries to muscles) (Oblakovic-Babic, 2005; Starkey,2000).

An *overuse* injury refers to an injury resulting from repeated micro trauma without a single, identifiable event responsible for the injury. An athlete sustained an overuse injury when he/she suffered a physical discomfort which caused pain and/or stiffness of the musculoskeletal system, and which is present during and/or after the basketball activity. (Cumps et al 2007; Junge et al. 2006,) It appears that overuse injuries account for between 12.8% and 37.7% of all injuries. tendinopathies, particularly patellar tendinopathy, are the most common overuse injury (Caine et al.2010)

A significant proportion of these injures remain difficult to treat, and many individuals have long-term pain and discomfort, which cause significant loss of performance and decreased functional capacity.

Risk factor and neuromuscular program

Numerous risk factors for traumatic and overuse lower extremity injuries in sport and especially in basketball players, have been identified through prospective studies, including: previous injury (McKay, 2001; Meeuwisse et al.2003) biomechanical alignment and anatomical factors. (Hewett et al., 2005; Shambaugh et al. 1991) tape or brace use (Grace et al.1998; Yang et al. 2005) shortened reflex response time (Witprouw et al.2000), decreased vertical jump height ((Witprouw et al.2000), being female (Gwinn et al. 2000; Messina et al 1999; Zelisko et al.1982), decreased muscle flexibility (Witvprow et al., 2000) and poor balance. ((McGwine et all., 2000).

It has been reported that neuromuscular control may be the most modifiable risk factor in the prevention of knee injuries (Griffin et al.2000; Hewett et al. 2005) In fact, it may improve dynamic lower extremity alignment upon landing from a jump, shock attenuation of peak landing forces, muscle recruitment patterns, and postural stability or balance (Hewett et al. 1999; Griffin et al.2000).

Various researchers have reported the effectiveness of neuromuscular training programs to decrease risk of lower extremity injuries in athletes. (Griffin et al.2000;Hewett et al. 1999;Mandelbaum et al. 2005; Pfeiffer et al. 2006).

Neuromuscular preventive programs was based on different design concepts and emphasizes different components of preventive exercise including plyometric exercises, strengthening, balancing, endurance and stability (Hewett et al., 2005; Hewett et al., 2006; Mandelbaum et a., 2005; Zazulak et al., 2007) .

Female basketball players, compared to male athletes, show an increased risk of lower limbs injuries. The highest incidence of injures is seen in adolescents playing pivoting sports such as football, basketball and handball. In particular, women are three to five times more likely to contract a serious knee injury than men (Arendt et al.1995; Myklebust et al.2003). Furthermore, they have the 25 % of possibilities of incurring in anterior cruciate ligament lesion (ACL) and traumatic knee injuries (Griffin et al.2000).

That research is designed for female basketball athletes with use the ball. In particular, the main aim investigate a number of non contact injuries in lower limbs during the period study in compliance with prevention program; and in secondary outcome, what was the influence of that neuromuscular warm-up on jumps and stability performance.

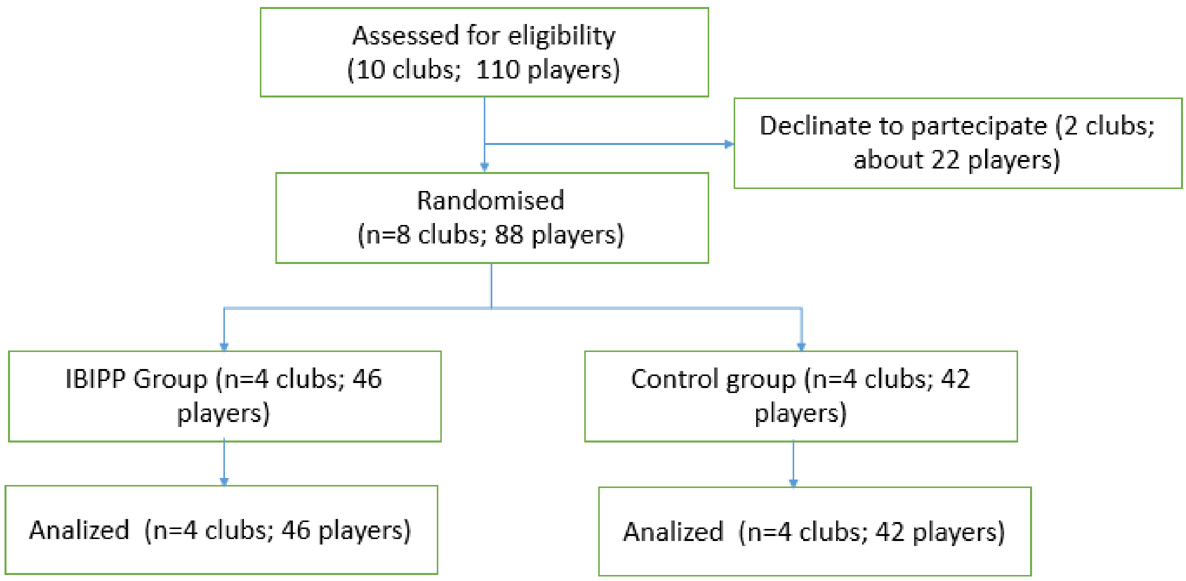
Methods

Experimental Design

Teams in the 15 year and 18 year divisions from Italy an organised by the Italian basketball Federation, received an invitation to participate in the study during the season (September 2013 to April 2014). The team practised 3 times per week and played between 30 to 45 matches during the season, depending on their ability and ambition. The teams were recruited from June to August 2014 through the training camp of Italian basketball Federation, and a letter with information about the purpose and the design of the study went to the coaches, who also informed the players.

A longitudinal study was used in this research and this intervention study covered 16 weeks seasons of female teams playing in regional basketball level. Subjects were asked to complete an initial visit to the laboratory for a fully familiarization with all testing procedure that comprises an anthropometric assessment (Height, weight and limb length) with anthropometer (Sieber Hegner-GPM) digital scale (Tanita TBF350 Illinois,USA), Y excursion balance test (Hertel et al.2006) (Y-Balance Test Kit™Move2Perform, Evansville, IN, USA)) Counter Movement Jump (CMJ) (Bosco et al. 1983) and one legged CMJ (Read, P..et al. 2013) (Optojump, Microgate, Bolzano, Italy).

Figure 4.4 - Flow of club clusters and players through the study



Operational definitions used in the registration of injury

Reportable injury

An injury occurred during a scheduled match or training session, causing the player to require medical treatment or miss part of or the next match or training session For each athlete an injury was defined as an event that would prevent the following: To be able to continue practicing or competing in a game and causes the absence from the following practice or game.

Player

A player was entered into the study was registered on the club roster by the coach, and did not have a major injury at the start of the study.

Return to participation

The player was defined as injured until he or she was able to participate fully in club activities (match and training sessions).

Type of injury

Acute—injury with a sudden onset associated with a known trauma

Overuse—injury with a gradual onset without any known trauma

Severity

Slight—0 days of absence and able to participate fully in the next

match or training session

Minor—absence from match or training for 1-7 days

Moderate—absence from match or training for 8-21 days

Major—absence from match or training for > 21 days

Exposure

Match exposure—hours of matches

Training exposure—hours of training

In nearly all cases, players sustaining moderate or major injuries were examined by a doctor. In case of a slight or minor injury, the player was often examined only by a physical therapist. None of the injured players was examined or treated by any of the authors, and we had no influence on the time it took a player to return to club activities.

Registration

Injury data were recorded by certified physiotherapist and strength and conditioning coaches. This coaches were provided with a standardized mechanism for reporting injuries. The information collected on these sheets included injury, anatomic location of the injury, conditions (practice or game), athlete’s age. Data were collected from the beginning of preseason practice to the final postseason game. Additional information was collected at the end of the season through questionnaires completed by each physiotherapist or strength and conditioning coach.

These reports included information to evaluate exposure time such as number of players on the roster number of practices per week and their duration, and total number of games played.

Injury Rate and Injury Risk

Injury rate was defined as the number of injured players divided by the number of players exposed to injury. This gives a rough estimate of the likelihood that an athlete will sustain an injury during the season. Injury risk per hour of exposure may give a more accurate assessment of injury frequency. Injury risk per hour of exposure is determined by dividing the number of injuries by the total number of player-hours of exposure. Exposure time was the total recorded game time and the total practice time calculated from the average practice time for all the teams during the season. (Messina et al. 1999; Wen et al.,2005; Knowles et al.,2006; Mc Alisteter et al. 2008; Stang et al.2010).

Participants

Eighty-six young, uninjured female, national level basketball players (16±2 y-o; 52.9±11.4 kg; 160±1 cm; 20.1±3.1 kg/m^2) were enrolled in a in a 16-wks protocol consisting of 3 session/week of 2 hours. The subjects in each group were similar in terms of age, height, and body mass. All participants engaged in sports activities three or more times a week. The subjects participated in an identical level of play and were exposed to similar basketball activity between duration of the study. Prior to testing, all subjects and their parent received and signed an informed consent approved by Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan (Italy) which stated how the subject's rights would have been protected. Individuals with prior history of lower extremity injury, in last 6 month, surgery of the lower extremity, or vestibular disorders were excluded.

Table 4.2 - Anthropometric characteristic at baseline

GROUP	N°	AGE (YEARS)	HEIGHT(CM)	WEIGHT(KG)	P
IBPP	44	15.9±0.8	171.2±7.3	62.1±7.4	n.s
CG	42	15.9±0.9	169.2±6	59.8±6.4	n.s

Testing procedures

Subjects were excluded if their self-reported pain, injury, or soreness to the lower back or lower extremities at the time of the test familiarization. Any injuries must have healed with a return to regular activity at least four weeks prior to participation. Those with a history of back or lower extremity pain, major previous surgery, bone, joint or muscular disorder history of neurological/orthopedic, or pain that would limit the ability to perform functional tasks correctly, were excluded. After completing the warm-up, the players were provided with detailed information on the research procedures. Participants were tested at baseline (BL) and at week 16 (W16). Every coach was given a form to indicate eventual injuries occurred during experimental time. The form of neuromuscular warm-up program was based on PEP (Prevention Injury and Enhancement Performance) (Mandelbaum et al. 2005).

Instrumentation and Measurements

Anthropometrical assessments

The same operator performed the anthropometric assessment before each experimental session. Body height and body mass was measured, then on the dominant side of each athlete was measured the length of the lower limb from the anterior superior iliac spine to the medial malleolus with a measuring tape to the nearest 0.1 cm in the supine position (Hinson et al.1998)

Vertical jumps test

Vertical jump testing is a common method used by coaches to assess jump height and muscular power. (Bosco et al. 1983; Bobbert et al. 1996; Ferragut et al. 2002; Fontani et al. 2005; Hespanhol et al.2007).

Significant correlations have been observed between vertical jump height, maximal strength ,muscular power (Sheppard et al. 2008) sprinting (Cronin et al. 2005), vertical jump testing is reliable and valid for the estimation of explosive muscular power with high reproducibility (Markovic et al, 2004; Slinde et al. 2008).

It is also a good indicator of the athletes' performance (Wilson et al.1995) and sensitive enough to detect changes after a specific training period (Stanganelli et al. 2008).

Vertical Jump Measurements with Counter Movement Jump (CMJ) (Bosco et al.19839 in according to the procedures suggested by Bosco et al. (1983). This test is characterized by a very good test-retest reliability (coefficients of variation of 3.0%) (Bosco et al. 1983; Markovic et al 2004).

All the jumps were measured using the Optojump system (Microgate, Bolzano, Italy). The Optojump is a dual-beam optical portable device that measures ground contact and flight time during a jump or series of jumps. The flight time (Tf) and the acceleration due to gravity (g) were used to calculate the vertical rise (h) of the center of gravity of the body.

There producibility of the vertical jump test results using the Optojump device has been shown to be excellent (Meeuwisse et al. 2003; Glatthorn et al.2011 and it has been used in other studies (Schiltz, et al. 2009; Settler et al. 2015).

Cmj and One Legged CMJ: Test execution:

Players performed a CMJ and an One leg Jump in according to the protocol described by Bosco et al. (5). Before testing, players performed self-administered submaximal CMJs and One Leg jump (2–3repetitions) as a practice and specific additional warm-up. Subjects were asked to keep their hands on their hips to prevent any influence of arm movements, for better execution to subjects were required to fully extend lower limbs at takeoff and to keep as stiff as possible their legs at landing (Borras et al. 2011).

To favour players in doing this, they were asked to perform submaximal stiff-leg bouncing at landing from the jumps of interest. Quality of jumps performed was checked by visual on-site inspection by the author of this study and by post hoc replay of the video footage collected by the 2 cameras that are considered by Optojump Next system. Only CMJ and One Legged CMJ that satisfied the criteria assumed were retained for calculations.

Each subject performed 3 maximal CMJ and One Legged CMJ in a random order, with approximately 2-minute recovery in-between. Players were asked to jump as high as possible, and the highest jump was recorded and used for analysis.

YBT-LQ Test

YBT-LQ requires neuromuscular characteristics such as lower extremity coordination, balance, flexibility and strength. Moreover, Plinsky et al. (2009) stated that poor performances on the YBT-LQ have been associated with elevated risk for non-contact lower extremity injury. McKeon et al.[45] and Filipa et al.(2010) reported that dynamic balance might be modified with neuromuscular training programs, suggesting that it might be possible to mitigate the elevated injury risk that was identified with the YBT-LQ.

YBT-LQ collection occurred using a previously established standardized testing protocol that has shown to be reliable (Plisky et al.2009; Filipa et al.2010). First, subjects viewed a standard video demonstration followed by six practice trials prior to testing (Plisky et al.2009).

YBT-LQ execution:

The testing order was 3 trials standing on the right foot reaching in the anterior direction followed by 3 trials standing on the left reaching in the anterior direction. This procedure was repeated for the posteromedial and then the posterolateral reach directions.

The YBT-LQ test was analyzed using the average of the last three trials for each reach direction for each lower extremity, as well as the average of the total of three maximum reach directions (composite score). The YBT-LQ composite score was calculated according to Plinsky et al. (2006) by dividing the sum of the maximum reach distance in the anterior (A), posteromedial (PM), and posterolateral (PL) directions by 3 times the limb length (LL) of the individual, then multiplied by 100.

$$\text{Eq 1: Composite Score} = \frac{(AA+PM+PL)}{(LL\ x\ 3)}\ x\ 100$$

The maximum value measured for each excursion direction was also analyzed, as well as summed composite score of the maximums for each lower extremity. In order to control for the effect limb length between subjects, YBT-LQ test values were normalized to percent of average anatomical limb length (average of right and lift sided).

YBT-LQ the testing order was 3 trials standing on the right foot reaching in the anterior direction followed by 3 trials standing on the left reaching in the anterior direction. This procedure was repeated for the posteromedial and then the posterolateral reach directions. For each tests it was recorded the maximum score.

Procedures

IBIPP (Italian basketball injuries prevention program) is a neuromuscular performance program which has been adapted to basketball with the aim to reduce the risk of legs, knees in particular, capsule ligamentous injuries. This program is based on the PEP model, i.e. Prevention Injury and Enhancement Performance model (Mandelbaum et al.2005) and doesn't require any additional equipment.

It should be taken on the basketball court in a limited time lapse (max 25'). Its peculiarity is the usage of the ball mainly during the initial and final phases of the warm-up.

All subjects were divided in two groups: 46 in the “ IBIPP group ” and 42 in a “Control” Group. The IBIPP program consisted of 20-22 minutes active stretching and mobility , strength, plyometric and agility basketball specific drills (with dribbling the ball) whereas the control group did the normal training routine. Coaches and strength and conditioning coaches filled out the attached form to monitor injuries. The program is divided in this way:

Table 4.3 - Neuromuscular prevention warm-up (IBIPP)

Exercises	Distance	repetitions/time
1. warm-up (dribbling the ball)		
-Jog line to line	4 basketball court	1
-Shuttle run	4 basketball court	1
-Lateral and backward running	4 basketball court	1
2 stretching		
-Leg swing front-to back/s ide to side	NA	1x12
-Lateral squats	NA	1x12
-Lunge w/superior reach	14 Meters	1
-Walking quad stretch	14 Meters	1
-Monster walks	14 Meters	1
-Inverted hamstring stretch	14 Meters	1
-Lateral crossover step	14 Meters	1
	14 Meters	1
	14 Meters	1
3 Strenghtening		
- Multidirectional lunges	NA	2X10 Bilateraly
-Nordic hamstrings	NA	2X5
-Single-toe raises	NA	2X 12 Bilateraly
-lateral bridge	NA	2x30" Bilateraly
4 plyometric		
Vertical jumps	NA	2X10
Lateral hops	2- to 6-in cone	2X20Bilateraly
Single-legged hops	2- to 6-in cone	2X20 Bilateraly
Forward hops	2- to 6-in cone	2x10
5 basket agilities (dribbling the ball)		
Four way close-out (no ball)	NA	4
Line drills and sprint	NA	4
Zigzag cones	NA	4
Four corners	NA	4
Pass-sprint and layup	NA	4

The complete program, with an addition exercises part, is attached in appendices.

Training was conducted 3 times a week (Monday, Wednesday, Friday) by strength and condition coaches (NSCA-NASM) and a basketball professional coaches certified.
The coaching staff was provided with all the documentation, also in terms of the preparation of the practice floor. Participants were educated by videotape and monitored only by coaches. Athletes were instructed to avoid dynamic knee valgus and to land jumps with flexed hips and knees. Coaches were taught how to emphasize and distinguish proper jump/land techniques from improper form. They were also taught how to use verbal cues to promote proper form (ex. “land softly” and “don’t let knees cave inward”) because research (Hewett et al.2006) shows that this feedback enhances effectiveness. The other suggests was toe toe-to to-heel rocking of the foot for decrease ground reactive forces, knees flexed, knees forward discourage inward buckling of knees and chest over knees (Hewett et al.1999; Mandelbaum et al 2005; Hewett et al.2006).
The training period lasted a total 16 weeks. The plyometric and dynamic-movement training component progressively emphasized double- then single leg movements through training sessions.

Data analysis

Adherence at the training program was registered.
The statistical tests were performed using Graph Pad Prism Software, version 6.00 for Mac OSX (Graph Pad Software, San Diego California USA).

The estimation of injuries and the risk reduction was calculated according to literature (Knowles S. et al,2006; Wen et al. 2005; Stanget et al. 2010; McAlister et al. 2008).

To determine the effect of the training intervention a two-way ANOVA with Tukey's multiple comparisons test was applied. Normality for each variable was assessed using the Kolmogorov-Smirnov test. All data was normally distributed. For all tests, the significance level was set at a p level ≤ 0.05.

Moreover, Cohen’s effects sizes (ES) (Cohen, 1988) [23] were calculated to assess magnitude of effects between pre and post and between groups. Values <0.2, <0.6, <1.2 and >2.0 were interpreted as trivial, small, moderate, large and very large respectively (Betterham et al. 2006).

Results

All participants completed the 16-weeks program with a mean adherence of 90%. No significant differences were found at BL in the two groups.

Comparison of the demographic data between the experimental and control group showed no significant difference in age, height, or mass (p>.005).

Significant reductions of injuries rate was detected only in the experimental group with 6 injuries in lower limbs (8 injuries total) on 2169 games and 4338 hours of activity, with incidence rate (IR) of 1.38 per 1000 hours exposure (SE 0.001); 95% confidence interval 0,28 to 2,49. on 1000 hours to incurring in a injury.

Epidemiological incidence proportion (IP) was 0,13; 95% confidence interval is 0.03 to 0.23 risk of injury as the number of injured athletes divided by the total number of athletes.

On the other hand, the control group was 14 injuries in lower limb (16 injuries in total) on 2060 games and 4120 hours of activity with an incidence rate (IR) of 3.38 per 1000 hours exposure (SE 0.001) 95% confidence interval 1.62 to 5.18.

In table 4.4 we reported a localization and typology of injury; in table 4.5 we reported an epidemiological data

Table 4.4 - Localization and typology of injury in lower limbs during 16 weeks

Type of injury	IBIPP Group	Control Group
Ankle sprain	3	5
Muscle strain	2	4
Knee sprain	0	1
Overuse pain	1	3
Acl lesion	/	1
Back pain	1	1
Leg contusion	1	1
Total	**8**	**16**
No contact lower limbs injury	**6**	**14**

Table 4.5 - Epidemiological data

	All injury	Injury Rate (IP 95% CI)	Clinical Incid.(IP 95% CI)	Epid.. Prop.(IP 95% CI)
IBIPP Group	6	1.38; 0,28 to 2,49	0,14; 0,03 to 0,24	0,13 ; 0,03 to 0,23
Control Group	14	3.40; 1,62 to 5,18	0,30; 0,17 to 0,44	0,33; 0,19 to 0,48

Legenda**:** Injury rate; Clinical incid.= Clinical incidence, Epid. Prop.= Epidemiological proportion

Rate ratio between groups (IC IBIPP group /Control group) 0,40 (<1) Sign. Chi-square 5,14
Epidemiological incidence proportion (IP) was 0.33, 95% confidence interval 0.23 to 0.53 .
Relative risk of injuries is 0,42% less on IBIPP group.
Number Needed to Treat (NNT/NNH) rates was 4.3: absolute risk reduction (ARR) 0,23.
On average, 4.3 patients/athletes would have to receive experimental treatment (instead of control treatment) for one additional patient to not have the study outcome.

Table 4.6 - IBIPP Group

Incidence Rate (injury per 1000 h exposure)			
N° Injuries	6	Epidemiologic IP	1,38
N° Athletes	44	SE (standard error)	0,001
durations of events (h)	2		
N° events in season	2169		
N° total hours (h)	4338		
level of confidence	0,95	**interval of confidence**	
α	0,05	Extreme inferior	0,28
F(Zα)	0,975	Extreme superior	2,49
Zα	1,96		

Clinical Incidence (n° injury/n° athlets)			
N° Injuries	6	CI	0,14
N° atheletes for team	44	SE (Errore Standar	0,05
level of confidence	0,95	**interval of confidence**	
α	0,05	Extreme inferiror	0,03
F(Zα)	0,975	Extreme superior	0,24
Zα	1,96		

**Table 4.7 - ** Control Group

Incidence Rate (injury per 1000 h exposure)			
N° Injuries	14	Epidemiologic IP	3,40
N° Athletes	42	SE (standard error)	0,001
durations of events (h)	2		
N° events in season	2060		
N° total hours (h)	4120		
level of confidence	0,95	**interval of confidence**	
α	0,05	Extreme inferior	1,62
F(Zα)	0,975	Extreme superior	5,18
Zα	1,96		

Clinical Incidence (n° injury/n° athlets)			
N° Injuries	14	CI	0,30
N° atheletes for team	46	SE (Errore Standar	0,07
level of confidence	0,95	**interval of confidence**	
α	0,05	Extreme inferiror	0,17
F(Zα)	0,975	Extreme superior	0,44
Zα	1,96		

Regarding the YBT at T16 compared to T0, for the right limb the IBIPP group reached a significant greater distance on composite score (from 85.0±6.2 to 87.8±7.4 cm; + 3.2% (p=0.001; ES=0.4) .

In addition, regarding the left limb the IBIPP group showed significant improvement in composite score (from 85.4±6.0 to 88.0±7.0 cm; + 3.0% (p=0.001; ES=0.4). In the control group no significant differences between T0 and T16 were founded. (figure 5.5.1-5.5.2)

Regarding the CMJ significant improvements at T16 compared to T0 in the IBIPP group from 29.9±3.1 to 32.7±3.6 cm; + 8.5% p<0.05; ES=0.9; and in One legged CMJ in right limb from 16.4.8± 2.8 to 18.2± 2.7cm; +10.5.% p<0.05; ES=0.8; and in left limb from 16.3.8±2.1 to 17.9±3.0 cm; +8.9.% p<0.05; ES=0.6. In the control group no significant differences between T0 and T16 were founded. (figure 5.6.1-5.6.2)

No significant differences were detected for the other parameters

The ICC (1,1) was based on the results of a repeated measures analysis of variance, which compared the test-retest trials of CMJ, One legged CMJ and YBT . The ICCs of CMJ was 0,91, One legged Jump right limb 0.88, left limb 0.85 respectively , instead the ICC (1,1) composite score for the right limb were 0.91, 0.88, 0.83 and 0.90 respectively. The ICC (1,1) of composite score for the left limb were 0.88, 0.90, 0.82 and 0.89 respectively.

Table 4.8- Vertical jumps and YBT-LQ results of IBIPP Group

TEST	PRETRAIN	POSTTRAIN	DIFFERENCE (%)	*P* VALUE	EF. SIZE
CMJ	29.9	32.7	8.5	p<0.05	0.9
CMJ RIGHT	16.4	18.2	10.4	p<0.05	0.8
CMJ LEFT	16.3	17.9	8.9	p<0.05	0.6
Y COMP.RIGHT	85.0	87.8	3,2	p<0.001	0.5
Y COMP.LEFT	85.4	88.0	3,0	p<0.001	0.4

Sign. *p-value*≤0,05

Table 4.9 - Vertical jumps and YBT-LQ results of Control groups

TEST	PRETRAIN	POSTTRAIN	DIFFERENCE (%)	*P* VALUE	EF.SIZE
CMJ	29.1	30.1	3.3	N.S.	0.3
CMJ RIGHT	16.4	17	3.5	N.S	0.2
CMJ LEFT	16.3	16.4	0,7	N.S	0.3
Y COMP.RIGHT	85.7	86.6	1.0	N.S	0.1
Y COMP.LEFT	86.7	87.6	1.1	N.S	0.0

Sign. *p-value*≤0,05

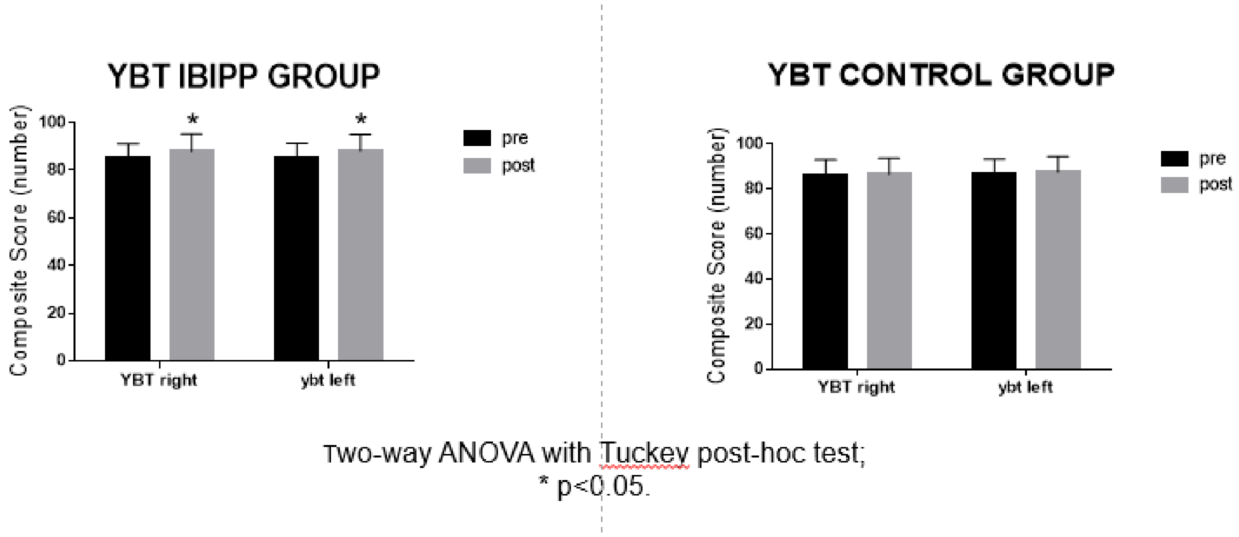


Figure 4.4.1 / 4.4.2 - YBT results

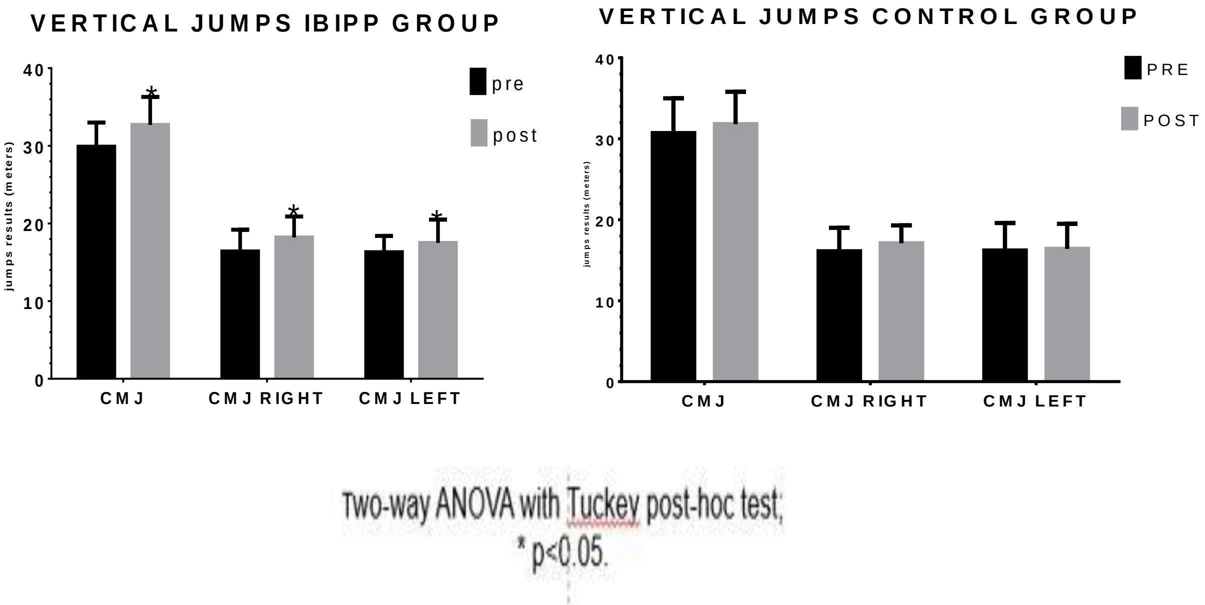


Figure 4.5.1/ 4.5.2 - CMJ and One Legged CMJ results

Discussion

The outcome of this study adds values to previous studies on different specific prevention injuries warm-up . That research is designed for female basketball athletes with use the ball. In particular, the main aim investigate a number of non contact injuries in lower limbs during the period study in compliance with prevention program; and in secondary outcome, what was the influence of that neuromuscular warm-up on jumps and stability performance.

After to neuromuscular warm-up program we noted a significate different injury rates between Experimental group (named IBIPP) and Control group, furthermore following 16 -weeks of neuromuscular warm-up intervention, the YBT composite score of both lower limbs significantly improved in the IBIPP group compared to non-trained control group. Same results in jumps tests, CMJ and One Legged CMJ.

In reference to main outcome we note as there is a wide range in the overall rate of injury in basketball and considerable variation in how rates are reported (hours of participation, athlete exposures (AEs), athlete per season, participant years, percentage of players) which reflects characteristics of specific surveillance methods and designs of basketball injury studies.
In general, most epidemiologic studies in basketball report a relatively low injury rate respect to other sports as soccer . The rates reported vary from 1.4 to 9.9 injuries per 1,000 AEs, depending on the definition used and the population sampled (Harmer 2010).

In this research the injury rate in IBIPP group is from 1,38 injuries per 1,000 AEs whereas in control group was 3,88 injuries per 1,000 AEs.

In other hand the athletes of IBIPP group was 0,28 to 2,49 on 1000 hours to incurring in a injury respect to control group was with a possibility of 1,98 to 5,79 on 1000 hours. with relative risk of injuries less on IBIPP group.

In IBIPP group was recorded 5 injuries included to slight and minor and 1 moderate. (overall 6).
In Control group was recorded 10 injuries included to slight and minor , 3 moderate and 1 major injury (overall 14).

In according with literature (Arendt 1999, Agel 2007, Ito 2015) the most of injuries in basketball was localization in lower limbs; 46.4% to 68.0% of injuries, in particular in ankle and in knee. Ankle injuries varies between 10.7% and 76.0% of all injuries while the rate of knee injury in American basketball players , accounting for 20% of all injuries (Deitch et al. 2006).

It appears that overuse injuries account for between 12.8% and 37.7% of all injuries; tendinopathies, particularly patellar tendinopathy, are the most common overuse injury (Obladovic-Babic 2005).

In college basketball sprains were experienced 37.1%, and in professional basketball sprains often accounted for about 27.8%. Other common injuries are contusions and strains (injuries to muscles). (Starkey et al. 2000; Oblakovic-Babic, 2005).

In our research in IBIPP group we reported 3 injuries in ankle (50% of trauma respect only lower limbs injuries and 37,5% respect to total injuries) while control group reported 5 injuries in ankle (35% respect only to lower limbs injuries and 31% respect to total incidents).

IBIPP group reported 1 overuse injury against 3 of control group (12,5 vs 21% respect to total injuries and 12,5 vs 18,7% respect only lower limbs) 2 muscle strain against 4 of control group ((25 vs 25 % respect to total injuries and 33 vs 28,7% respect only lower limbs).

Nothing ACL tears in IBIPP group was recorded vs 1 ACL tears in control group was recorded.

Regard knee injury, it is well known that the incidence of non-contact ACL injury is higher among female athletes than among male athletes. (Agel et al. 2005; Arendt & Dick, 1995; Bjordal et al.1997; Hootman et al., 2007; Mountcastle et al. 2007).

A video analysis study indicates a frontal plane “valgus collapse” mechanism for non-contact ACL injury in women. (Starkey et al. 2000). Non-contact ACL injuries often exhibit a common body posture that involves a valgus collapse of the knee joint, with the knee near full extension (between 0º and 30º) and an external tibial rotation with the foot planted during a deceleration maneuver.9,10 Dynamic valgus collapse is the most common ACL injury mechanism for female handball and basketball players. (Boden et al.2000; Olsen et al. 2004; Krosshaug et al. 2007; Quatman et al. 2009)

Female basketball players have a 5.3-times higher relative risk of valgus collapse during ACL injury, compared with male basketball players. (Krosshaug et al. 2007)
In according to an International Olympic Committee current concept, risk factors for female athletes suffering ACL injury include 1) being in the preovulatory phase of the menstrual cycle, compared with the postovulatory phase; 2) having a decreased intercondylar notch width on plain radiography; and 3) the development of an increased knee abduction moment (a valgus intersegmental torque) during impact onloading. Thus, sex hormones, dynamic neuromuscular imbalance, and anatomy may play a role in the increased risk of non-contact ACL injury in female athletes. (Dugan et al.2005; Renstrom et al.2008)

In references of competition versus training time of injuries, during practice rather than games in organized competitive basketball., Dick et al. (2007) found that the rate of injuries in games was two times greater than in practice in professional American basketball, (Deitch et al. (2006) reported that female players were injured more frequently at practices as compared with games, while Starkey et al. (2000) reported that 43.2% of injuries in male players over a 10-year period occurred during a game.

In our pilot study the we reported 17% on injuries in lower legs , occur in games, therefore we reported a more injuries in practice respect to game. A explanation could be a limit of time of study or a season period (first part of competitive season in that study respect to complete season of analysis) and a limited numbers of subjects.

Prior to program, both the experimental and the control groups demonstrated similar performance in the YBT and in CMJ and One Legged CMJ in all measured variables. In the end of 16 -weeks of neuromuscular warm-up intervention, the YBT composite score of both lower limbs and jumps tests was improved.

Latin et al. (1994) measured the physical abilities of elite male collegiate players identifying that high levels of strength and anaerobic parameters enable more powerful rebounds, in addition to enhanced shooting, shuffling, and jumping performances. In addition, the ability to repeat this explosive action across the course of a game is also of great importance, with reports of 44–46 jumps during a game . (Latin et al. 1994; McInnes et al. 1995, Abdelkrim et a. 2007)

Consequently, jumping is a key determinant to basketball performance and should form part of the athlete assessment strategies. Ineffective absorption of impact forces has been noted within basketball (Erculy et al. 2010). In particular, it was high lighted that females demonstrated inadequate abilities to withstand eccentric forces on landing. This is an important consideration for athletic trainer or coaches because of increases in injury risk, in addition to an inability to effectively use elastic energy accumulated in the eccentric phase of the jump (Bobbert et al 1996)

In according with Bracic et al 2010, Theoharopoulos & Tsitskaris (2000) reported on Read et al. (2013) and Delexetrat (2009) we used One legged CMJ with jump test for determine power ratios and imbalances between limbs, also said the basketball as expected a change of direction, lay out exc.. Where the players used movements with single leg position.

The players of IBIPP group in the current study showed improvements in YBT composite score when compared to non-trained controls.
We decided to test our athletes with YBT protocol because is a validated and reliable derivation of the Star Excursion Balance Test, that has been previously used to screen individuals for limitation in dynamic balance (Plinsky et al., 2009). Poor performances on YBT have been associated with elevated risk of non-contact lower extremity injury (Plinsky et al., 2006).

Plinsky et al., (2006) founded that girls with composite reach distance less than 94.0% of their limb length were more than 6 times more likely to have a lower extremity injury.

At the end of our training program, IBIPP group improved the composite score for the right limb from 90.8 % to 94.5% (+3.9%, p=0.005), and for the left limb from 91.2% to 94.2% (+3.1%, p=0.005) respectively. Our result confirm an improvement of the postural stability that for Plinsky et al.(2006) involves a possible reduction of the risk for future lower limb injury.

So our data confirm another time that YBT may have the potential to be a corollary outcome measure that can be utilized to assess lower extremity stability, monitor rehabilitation progress, assess deficits following injury and identify athletes at high risk for lower extremity injury.(Plinsky et al. 2009).

It has been reported that neuromuscular control may be the most modifiable risk factor in the prevention of knee injuries. (Griffin et al. 2000; Hewett et al. 2005). In fact, it may improve dynamic lower extremity alignment upon landing from a jump, shock attenuation of peak landing forces, muscle recruitment patterns, and postural stability or balance (Hewett et al. 1999; Griffin et al. 2000).

Various researchers have reported the effectiveness of neuromuscular training programs to decrease risk of lower extremity injuries in athletes. (Hewett et al. 1999; Griffin et al. 2000; Mandelbaum et al.2005; Hewett et al 2006; Pfeiffer et al. 2006; LaBella et al.2011).

Effective implementation of practical neuromuscular warm-up strategies can reduce lower extremity injury incidence in young, amateur, female athletes and male and female military recruits. (Herman et al. 2012). This is typically a warmup strategy that includes stretching, strengthening, balance exercises, sports-specific agility drills and landing techniques applied consistently for longer than four consecutive months. (Herman et al. 2012).
This neuromuscular warm-up was designed on previous injury prevention research (Hewett et al., 2006; Hewett et al., 2005; Mandelbaum et a., 2005 Zazulak et al., 2007, Mckeon et al., 2008; Filipa 2010) supporting the incorporation the ball , adapted it of basketball court and doesn't require any additional equipment.

In addition, we decided to incorporate body weight plyometric exercises in our neuromuscular training program because they trains the muscles, connective tissue, and nervous system to effectively carry out the stretch shortening cycle and focuses on proper technique and body mechanics appears to reduce serious ligamentous injuries. Such adaptations may be better preparing an athlete for more multidirectional sport activities and correct neuromuscular imbalances in female athletes (Lloyd et al.2001).

In support of this the studies by Hewett et al. (1999) , Huston et al. (2000) [27], Myklebust et al. (2003) [28] and Mandelbaum et al. (2005) incorporated high-intensity jumping plyometric movements that progressed beyond footwork and agility into their intervention designs. The studies by Heidt et al. (2000) and Soderman et al. (2000) did not. All 3 studies that incorporated plyometric exercises reduced anterior cruciate ligament risk, whereas the 2 studies that did not incorporate plyometric exercises did not reduce anterior cruciate ligament injury risk.

Huston et al., (2000) implemented a prevention study in 2 division I basketball program over a course of 8 years geared at changing player technique, stressing knee flexion on landing, using accelerated rounded turns, and decelerating with a multistep stop. They noted an 89% reduction in the rate of current anterior cruciate ligament injuries in their intervention group. Finally the cohort study over two years of Mandelbaum et al. (2005) for determining whether a neuromuscular and proprioceptive performance program was effective in decreasing the incidence of anterior cruciate ligament injury within a select population of competitive female youth soccer players, reported that during the two season, there was an 88% decrease in anterior cruciate ligament injury in the enrolled subjects compared to the control group.

Moreover, decreased neuromuscular control of the trunk appears to influence dynamic stability of the lower extremity during high-speed athletic maneuvers (Zazulak et al., 2007) .

Current literature supports the use of neuromuscular training programs that incorporate the use of core stability as part of treatment to prevent injuries of the ankle and knee (McKeon et al. 2008; Zazulak et al.2007) . For this reason we chose of used core exercise as side bridge (and other exercises in addition program) in that prevention warm-up.

A meta-analysis indicated that multi-intervention program may reduce lower limb, acute knee and ankle injuries and that balance programs may reduce ankle injuries (Hubscher et al.2009). However, the practicality of these findings for many team may be limited due to the need for equipment purchases (for example, balance boards) and the requirement of additional training sessions to normal practice and competition. In these cases, a more practical solution would be a compass neuromuscular training program which do not require additional equipment and may be incorporated into warm-up or current routines easily incorporated into regular activity. (Hewett et al. 2005)

Conclusion

The IBIPP program, through a functional neuromuscular skill specific to basketball play, has shown to reduce the incidence of no contact injuries on the lower limbs in young female regional basketball players. The definition of a prevention program, feasible during a practice session, is essential for the protection of the players; especially in the adolescent stage.

The IBIPP program was influence on vertical jumps and on dynamic stability; in fact the IBIPP group was a significant improvement in each test. This improve could have a impact on performance of players and on prevention injury risk. In order to optimize these strategies, the mechanisms for their effectiveness require further evaluation

That research might be improved to develop a better contextual model of evidence that might be used by patient/athletes–clinician and laboratory oriented (PCL) model of classification evidence (McKeon et al 2011)

Future researches would be required to assess the possibility of using this strategy in other sports especially for female athletes. An important parameter to change is the number of enrolled subjects.

Practical application

Using the prevention program in youth basketball women is important for athlete’s health and the same time to enhance the performance. The role of the strength and conditioning coach and the medical staff is basic to control and suggest the players a correct exercise execution.

However, the key is the use of neuromuscular training program which do not require additional equipment and which can be incorporated into warm-up or current routines especially in young team.

Publications

Scientific Papers

Acute effects of whole-body cryotherapy on sit-and-reach amplitude in women and men

Cryobiology xxx (2015) 1-3 http://dx.doi.org/10.1016/j.cryobiol.2015.10.148

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Abstract

Flexibility is an intrinsic property of body tissues, which among other factors determines the range of motion (ROM). A decrease in neural activation of the muscle has been linked with greater ROM. Cryotherapy is an effective technique to reduces neural activation. Hence, the aim of the present study was to evaluate if a single session of whole-body cryotherapy (WBC) affects ROM. 60 women and 60 men were divided into two groups (control and experimental). After the initial sit-and-reach test, experimental group performed a 150 s session of WBC, whereas the control group stayed in thermo-neutral environment.

Immediately after, both groups performed another sit-and-reach test. A 3-way analysis of variance revealed statistically significant time _ group and time _ gender interaction. Experimental groups improved sit-and-reach amplitude to a greater extend than the control group. Our results support the hypothesis that ROM is increased immediately after a single session of WBC

Body weight neuromuscular training improves performance on Lower Quarter Y-Balance Test™ in female National basketball players

Journal of Athletic Trainer (JAT) **Accepted in date: 4 febbrary 2016**

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Abstract

Aim of this study was to investigate if a bodyweight neuromuscular warm-up routine could improve performances on Lower Quarter Y-Balance Test™ (YBT-LQ) in female basketball players. Twenty-eight healthy female subjects were randomized, on the basis of the composite score of YBT-LQ, to a bodyweight neuromuscular warm-up group (NWG) or to standard warm-up group (SWG) routine. Subjects were tested at baseline (T0) and after 8-week of training (T8) during the Italian basketball regular season. In each testing session data on anthropometry and YBT-LQ were collected. The neuromuscular warm-up strategy focused on core stability, plyometric and body weight strengthening exercises. All data were assessed for their reliability with calculation of interclass correlation, changes between T0 and T8 were assessed by paired t-test and change differences between groups by un-paired t-test. The NWG improved significantly the performances on YBT-LQ for posteromedial (right: +3.6%, ES=0.9, left: +4.3%, ES=1.0) posterolateral (right: +3.7%, ES=1.0; left: +3.6%; ES=1.1) and composite score (+5.4%; ES=2.1; left: +5.8%; ES=2.0). No differences for the anterior direction were detected. Differences between NWG and SWG on posteromedial (right $p<0.05$; left: $p<0.01$) and composite score (right $p<0.01$; left: $p<0.01$) were founded. These findings illustrate that this type of neuromuscular warm-up strategy could improve performances on YBT-LQ, with an improvement of lower extremity stability, and therefore a reduction of lower limb injuries. In conclusion this type of training is just as effective as protocols that involves equipment that are less portable, more expensive, and possibly less practical during the training sessions.

Keywords. Body weight strengthening; core stability; plyometric exercises; composite score; lower limb stability.

Hand grip strength and anthropometric characteristics in Italian female national basketball teams

The Journal of Sports Medicine and Physical Fitness **Accepted in date: 24 febbrary 2016**

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ABSTRACT

The aim of this study was to investigate the influence of hand and body dimensions on hand grip strength, to define a reference scale for talent identification in basketball players.

Body and hand anthropometric data and the maximal handgrip strength of 109 female Italian basketball National players (Under14-Seniores) were measured.

Handgrip strength and arm length trend increase, raising the statistical significant differences only from 19 aged players (U20, Seniores) with respect to sub-elite groups (U14, U15) ($p<0.05$). Handgrip strength showed low positive correlations with height and BMI but a positive relationships with arm length ($r=0.5$; $p<0.001$). Findings underline training and years of practice effects on handgrip strength increasing.

Data show that to select female basketball players by arm length means to select by handgrip strength. Thus it is possible to suggest that in addition to height, also arm length could be considered an useful parameter in young female talent identification.

Keywords: Anthropometric measures - Handgrip strength – Basketball Players – Talent identification

Paper under review

Prevention of lower limbs injuries in youth female basketball players: A pilot study

Journal of Athletic Trainer (JAT)

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Abstract

Context:

Basketball is one of the most popular sports, and it is also one of the highest contributors to sport and recreation-related injuries. As the sport grows, in terms of number of participants and intensity, so does the number of injuries. Female basketball players, compared to male athletes, are characterized by an increased risk of lower limbs injuries.

***Objective*:** Aim of this pilot study was to investigate the effects the specific prevention injuries warm-up designed for female basketball athletes.

***Design*:** Longitudinal controlled study.

Setting: Female team basketball: national level in Italy.

Patients or Other Partecipants: Eighty-six young, female, regional level basketball players (age 16±2 y-o; 52.9±11.4 kg; 160±1 cm; 20.1±3.1 kg/m^2) were enrolled in a 16-wks protocol consisting of 3 session/week of 2 hours.

Interventions: Consisted of education, stretching, strengthening, plyometrics, and sports-specific agility drills designed to replace the traditional warm-up.

Main Outcome Measures: The number of non contact injuries in lower limbs during the period study in compliance with prevention program.

Results: Experimental group had a incidence rate (IR) of 2,25 per 1000 hours exposure with a possibility of 0,69 to 3,80 on 1000 hours to incurring in a injury; Epidemiological incidence proportion (IP) was 0,18 with 0,07 to 0,30 risk of injury/athletes.

The control group had with an incidence rate (IR) of 4,61 per 1000 hours exposure with a possibility of 2,48 to 6,74 on 1000 hour to incurring in an injury. Epidemiological incidence proportion (IP) was 0,43 with 0,28 to 0,58.
Relative risk of injuries is 0,51% less on IBIPP group respect to control group.
Number Needed to Treat (NNT/NNH) rates was 3,7: absolute risk reduction (ARR) 0,27
Experimental group showed significant improvements in CMJ (ES 0.8) one-legged CMJ right leg (ES 0,8) CMJ left leg (ES 0,6) and Y excursion balance test for both legs (ES 0,5-0,4) , compare the control group we didn't find any significant differences.

Conclusion:The prevention program called I.B.I.P.P. through a neuromuscular warm-up specific for basketball , has shown to reduce the incidence of injuries non contact lower limbs in young female regional basketball players.

Keywords:

Female basketball, Injuries prevention, incidence rate, risk of injuries.

Consecutive whole-body cryotherapy sessions as a new approach to teacher stress management

Journal of Occupational Health Psychology

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Abstract

In current times there is a strong business care for preventing stress and psychosocial risks at work. The aim of this study was to investigate the impact of ten sessions of whole-body cryotherapy (WBC) on various parameters of wellbeing, mental state and quality of life in female primary school teachers. Thirty healthy female teachers of the primary school were recruited for this study.

Subjects were randomly divided in two groups: WBC group (n=15) which underwent 10 WBC sessions for a two week course and control group (n=15). All subjects filled out a questionnaire at two time points – before the start of the study (T1) and at the end of the treatment (T2).

The Psychological General Well-Being Index (PGWBI), the Teacher Stress Inventory (TSI), the Brief Cope and the Teacher Satisfaction Scale (TSS) were utilized in this study. The measurements were shown to lead to an appreciable significant difference after completing the WBC cycle than before its commencement ($p<.01$). It is evident from the results that after 10 consecutive WBC sessions the dynamics of improvement in the experimental group was much greater than in the control group. Ten sessions of whole-body cryotherapy performed in cryo-cabin clearly lead to improve teachers well-being and quality of life. Our results suggest that WBC can be successfully applied to a wide range of population aiming to prevent stress disorders.

Keywords: Whole-body Cryotherapy; Wellbeing; Quality of life; Teacher Stress; adjuvant therapy

Congress experience

Oral presentation

20th Annual Congress of the European College of Sport Science – 14nd - 16th June 2015, Malmoe – Sweden

The effects of 8 weeks of plyometric training on sprint and jump performance in female high school basketball players

Authorship:

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3.ATS Trainer

Aim:

Many studies of match-analysis have recorded a great number of jumps, sprints and change of direction during a basketball competitions (Ben Abdelkrim et al., 2007; McInnes et al., 1995). Although these high intensity activities represent a small portion of the total game time, causing 42% of the energy expenditure, they are believed to be very important for the result of a match. The aim of this study is evaluate the influence of plyometric program on sprint and jump performance in female basketball players.

Methods:

Twenty-four young female basketball players (15.9±0.8 y-o; 170.7±7 cm; 61.5±8.2 kg) were involved in a 8-wks protocol consisting of 2 session/week with 6/7 exercises in accordance with NSCA plyometric guideline. All subjects were divided in two groups: 12 in a Training Group (TG) and 12 in a Control Group (CG) that performed the normal training routine of technical basketball drills. Subjects were tested at baseline (BL) and at week 8 (W8). Vertical jump performance (height) was measured by using the Optojump system (Microgate, Italy) and sprint over 20 meters was measured using Polifemo Photocell system (Microgate, Italy).

Results:

All participants completed the 8 weeks program. A paired T-test and a unpaired T-test were used respectively to assess pre-post differences within groups and between groups. Results were expressed as mean ± SD. Significant differences were found at $p<0.05$. The experimental group at W8 showed significant improvements in vertical jump height for both CMJ test and Stifness test, whereas no significant result were founded in sprint performance (ES 0.2). The control group did not show any significant difference at W8 compared to BL. No significant difference between groups with unpaired T-test although very positive effect sizes for all variables in post-training differences.

Conclusion:

The study shows how a simple and short program of plyometric exercises has a significant influence on the vertical jump height in young female basketball players.

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Ben Abdelkrim et al. (2007) Br J Sports Med; Vol. 41 - Issue 2: 69–75.

McInnes et al. (1995) J Sport Sci; Vol. 13 - Issue 5:387-97

Acute effects of self myofascial release on single leg stability and vertical jump: a pilot study

Authorship:

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3.ATS Trainer

Introduction:

Self myofascial release (SMR) with foam roller is very popular among athletes and trainers. Practitioners, usually, use it before the training session because it is documented that SMR increases the articular ROM but does not affect neuromuscular characteristics (Healey et al., 2014; MacDonald et al., 2015). Previous studies did not use an SMR protocol on all the lower limb muscle as often happens during the field practice. The aim of the study is to measure the acute effects of a whole lower limb SMR protocol on single leg stability and vertical jump performance.

Methods:

Eighteen young heatlh and sporty people (10 male and 8 female: 24.5±4.5 y-o; 167.2±9,4 cm; 62.1±10.3 kg) were involved in a single session protocol consisting of: a bief warm up, CMJ test, single leg stability test, 20 minute of lower limb SMR procedure, CMJ test, single leg stability test. CMJ and single leg stability tests were performed respectively by 10 and 18 people. The SMR protocol lasted 60" for each of the following muscular districts: plantar fascia, calves, tibialis anterior, peroneals, hamstring, quadriceps, gluteus, adductors, tensor fasciae latae of both legs. CMJ performance was measured by using a Bosco's condictive device (TT Sport, San Marino Republic).

Single leg stability was measured both in Open Eyes condition (OE) and in Closed Eyes condition (CE) by using a FreeMed 40x40 platform (Sensor Medica, Italy). A Student's T-Test was used to assess the difference pre-post SMR protocol. Statistical significance was set at $p<0.05$.

Results:

CMJ showed a 7% significant decrease ($p=0.010$) between pre (35.5±9.4 cm) and post (33±8 cm) SMR protocol. Single leg stability did not show any significant difference for the right leg both in OE and in CE condition, while showed just a little significant difference ($p=0.041$) in for the left leg in OE condition for the anterior-posterior movement.

Discussion:

The study shows how a longer SMR protocol on all muscles of the lower limb does not alter the stability in OE and CE condition, but it can affect the vertical jump performance, maybe for the prolonged lying on the ground position, as well as a static stretching procedure. It is very important for trainers and athletes to take this result into consideration in programming the warm up session. This pilot study will be implemented with other future tests but it is recommended to insert a brief neuromuscular activation after the SMR procedures to avoid any lowering in explosive movements.

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19th Annual Congress of the European College of Sport Science – 2nd - 5th July 2014, Amsterdam – The Netherlands.

A pilot study for the prevention of lower limbs injuries in youth female basketball players

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Introduction

Female basketball players, compared to male athletes, are characterized by an increased risk of lower limbs injuries. For this reason, aim of this pilot study was to investigate the effects the Italian Basketball Injuries Prevention Program (IBIPP) especially designed for female athletes

Methods

Forty-five young, female, regional level basketball players (16±2 y-o; 52.9±11.4 kg; 160±1 cm; 20.1±3.1 kg/m^2), were enrolled in a in a 16-wks protocol consisting of 3 session/week of 2 hours. All subjects were divided in two groups: 23 in the “IBIPP Group” and 22 in a “control” group. The IBIPP program consisted of 25 min active mobility, strength and agility exercises whereas the control group did the normal training routine. Subjects were tested at baseline (BL) and week 16 (W16) by Y excursion balance test, Counter Movement Jump (CMJ) and one legged CMJ (Optojump, Microgate, Bolzano, Italy). Adherence at the training program was registered and the estimation of injuries was calculated according to the study of Knowles et al., 2006. Differences over time were assessed with paired T-test and differences between groups with unpaired t-test. Results were expressed as mean ±SD. Significant differences were found $p<0.05$.

Results

All participants completed the 16-weeks program with a mean adherence of 90%. No significant differences were found at BL in the two groups. At W16, experimental group showed significant improvements in CMJ (ES 0.8) one-legged CMJ right leg (ES 0.8) CMJ left leg (ES 0.6) and. Y excursion balance test for right leg (ES 0.5) and for left leg (ES 0.5). Regarding the control group we didn't find any significant differences at W16 compared to BL. There isn't significant difference between groups with unpaired t-test in CMJ one-legged CMJ and Y excursion balance test. For the other parameters non-significant differences were detected. Significant reductions of injuries rate was detected only in the experimental group with 4 injuries on 890 games and 1781 hours of activity, with incidence rate of 2.3 per 1000 hours exposure (SE 0,0011) with a possibility of 0,05 to 4,45 on 1000 hours to incurring in a injury. On the other hand, the control group had 10 injuries on 1036 games and 2072 of activity with an incidence rate of 4,83 per 1000 hours exposure (SE 0,0015) with a possibility of 1,84 to 7,82 on 1000 hour to incurring in an injury.

Discussion

The IBIPP program, through a neuromuscular, resistance and mobility training, has shown to reduce the incidence of injuries in young female basketball players.

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6rd National Congress at Scuola Italiana delle Scienze Motorie e Sportive , 26th – 28th Sept 2014, Napoli (Italy)

The effects of neuromuscular training on vertical jump in young female basketball players

Authorship: R.Benis[1], A.La Torre[1]

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Aim:

Vertical jump (VJ) is one of the most prevalent acts performed by basketball players. Jumping acts are part of various defensive (e.g., blocking, rebounding) and offensive (e.g.rebounding and shooting) maneuvers performed by basketball players in practices and games (Ziv et al.2009).

Aim of this study is to measure the influence of neuromuscular training program on vertical jumps in female young basketball players.

Methods:

Fifty-five healthy regional players (16±2 y-o; 62.9±8.4 kg; 174±7 cm; 20.8±3.1 kg/m^2) were involved in a 9-wks protocol consisting of 3 session/week of 2 hour of basketball practices. All subjects were divided in two groups: 30 in the “NMTP group” and 25 in a “control group”. The 20 min NMTP consisted in core endurance, plyometrics and strength exercises whereas the control group did the normal training routine. Subjects were tested at baseline (BL) and week 9 (W9) by Counter Movement Jump (CMJ) and one legged CMJ (Optojump, Microgate, Bolzano, Italy). Differences over time were assessed with paired T-test and differences between groups with unpaired t-test. Results were expressed as mean ±SD. Significant differences were found $p<0.05$

Results:

All participants completed the 9 weeks program with a mean adherence of 90%. No significant differences were found at BL in the two groups. At W9, experimental group showed significant improvements in CMJ (ES 0.8) one-legged CMJ right leg (ES 0.8) CMJ left leg (ES 0.6).

Regarding the control group we didn’t find any significant differences at W9 compared to BL. There is significant difference between groups with unpaired t-test in CMJ and one-legged CMJ.

.**Conclusions:**

The study shows how a neuromuscular training program has produced a significant improvement in vertical jumps in female basketball players.

This conclusion is very important for coaches because the NMTP, usually used for prevention injuries, have influence on performance.

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21rd National Congress at Associazione Antropologica Italiana , 3th Sept – 5st Sept 2015, Ravenna (Italia)

Title: **Anthropometric and biomechanical contribution in basketball players selection**

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Introduction

Handgrip strength is very important in basketball, in fact, various movements rely on the continuous use of wrist and digit flexors in catching, holding, shooting and throwing handgrip (Visnapuu & Jurimae 2007, Cortis, Tessitore et al. 2011).

Upper extremity muscle strength and grip strength are the primary factors affecting passing accuracy. Handgrip strength is an important measure of general health and is regarded as one of the most reliable clinical methods for estimating strength (Groslambert, Nachon et al. 2002, Hager-Ross & Rosblad 2002)**.**

Aim:

The aim was to investigate if there is an influence of the hand dimensions on hand grip strength, if they are related to body dimensions and to define a reference scale for talent identification.

Methods:

Female Italian basketball national players (109 subjects Under14-Seniors) were examined about anthropometric and hand strength characteristics**,**We measured body mass, height, hand length and breadth (ISO7250-1- 2008), maximum hand spread (five fingers' span) (Peebles and Norris, 1998-Visnapu and Jurimae, 2007), maximal handgrip strength (Mathiowetz et al.,1985, by Jamar Hydraulic Hand dynamometer).

Results:

Handgrip strength trend increase, as well as age/sport level, raising the statistical significant difference only after 19 years aged players respect to younger, and for dominant (right) hand only in Seniors. It's possible that higher values and asymmetry were induced by strength training. No differences were showed for hand length as expected, but neither for breadth anatomical measures nor for functional dimension as hand span. Furthermore, comparing stature and hand length with not athletes Italian adult females (Masali, 2013; Fubini et al., 2011), the national basketball athletes values are near the highest percentiles, but not the hand length. Moreover, body dimensions show low correlations values with handgrip strength.

Conclusion:

We concluded that anthropometric selection in basketball players, generally based on stature values already in young athletes, select indirectly also by hand length, but not by breadth and span, and least of all by handgrip strength. We suggest to consider hand grip strength to aid talent identification at a young age and to increase it by training

7rd National Congress at Scuola Italiana delle Scienze Motorie e Sportive , 2th – 4 th Octob. 2015, Padova (Italy)

Title: **Body weight neuromuscular training improves performance on Y-Balance Test in female National basketball players.**

Authors:

Roberto Benis[1], Matteo Bonato1, La Torre Antonio[1]

1.Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan, Italy

Aim:

Lower Quarter Y-Balance Test (YBT) is a functional and inexpensive postural control measurement tool that can identify individuals at an elevated risk of injury (1). The aim of this study was to investigate if bodyweight neuromuscular intervention could improve performances on YBT in female basketball players in order to postural stability and therefore a reduction of lower limbs injuries.

Methods:

In this longitudinal randomized controlled study,twenty-eight healthy female basketball players (age: 20±2 years old; body mass 63±7 kg; height: 1.72±0.07 cm; weekly training volume 7±1 hours) volunteered participated to the study. Subjects were randomized into training group (n=14) and control group (n=14). All subjects were tested at baseline and after 8 weeks of conventional basketball training program during the national regular season. In each testing session data on anthropometry and YBT were collected. The experimental group underwent instead of the standard warm-up, 30 min of body-weight neuromuscular training intervention using plyometric and core stability exercises, designed for improve lower extremity strength and core strength.

Results:

The two-way repeated measure analysis of variance ANOVA shows that the experimental group significantly improved posteromedial ($p<0.05$) posterolateral ($p<0.05$) and composite score ($p<0.01$) of YBT for both limbs. No differences for the anterior direction for both groups were detected. In addition, the experimental group significantly improved the performances on posteromedial (right $p<0.05$; left: $p<0.01$) and composite score (right $p<0.01$; left: $p<0.01$) respect the control group.

Conclusions:

These findings illustrate that this type of body-weight neuromuscular training used as warm-up improve lower extremity stability assessed with YBT in junior female basketball players reducing therefore the risk lower limb injuries. In addition these findings demonstrate that this type of protocol is just as effective as protocols that involves equipment that are less portable, more expensive, and possibly less practical during the training sessions.

References:

Plisky PJ, Gorman PP, Butler RJ, Kiesel KB, Underwood FB, Elkins B. The reliability of an instrumented device for measuring components of the star excursion balance test. *N Am J Sports Phys Ther.* 2009;4(2): 92-99.

Poster presentations

9rd Congress ICST , 23th Oct – 25 th Oct 2014, Abano Terme (PD-Italy)

The effects of neuromuscular training on upper body strength in young students

Authorship:

Roberto Benis, Marta Roncelli, Lorenzo Pugliese, Matteo Giuriato, Antonio La Torre.

Department of Biomedical Science for Health, Università degli Studi di Milano, Milan Italy

Aim of this study is to measure the influence of a trunk and lower limbs neuromuscular training program on upper limbs strength in young students of secondary school.

One-hundred twenty-four students of secondary school (16±2 y-o; 62.9±8.4 kg; 174±7 cm; 20.8±3.1 kg/m^2) were involved in a 9-wks protocol consisting of 2 session/week of 1 hour of physical education. All subjects were divided in two groups: 79 in the “experimental group” and 68 in a “control group”. neuromuscular program consisted in core endurance, plyometrics and strength exercises with use of body weight, instead the control group performed the normal physical education lessons plane. The program provides trunk and lower limbs activity without exercises for upper limbs. Subjects were tested at baseline (BL) and week 9 (W9). Upper body strength is measured with a hand grip dynamometer. A paired T-test and a unpaired T-test were used respectively to assess pre-post differences within groups and between groups. Results were expressed as mean ± SD. Significant differences were found at $p<0.05$. The experimental group at W9 showed significant improvements in hand grip test with dominant hand. The control group did not show any significant difference at W9 compared to BL. The study shows how a neuromuscular training program, designed for trunk and lower limbs, has a significant influence on the isometric upper limbs strength in young students.

References

1. Sartorio A. et al. (2002) The impact of gender, body dimension and body composition on handgrip strength in healthy children. *J. Endocrinol. Invest.* 25:431–435.

2.Massy-Westropp et al.: (2011) Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Research Notes* 4:127.

3.Griffin LY, et al.(2005) Noncontact anterior cruciate ligament Injuries: risk factors and prevention strategies. *J Am Acad Orthop Surg 2;8:141-150.*

9rd Congress ICST , 23th Oct – 25 th Oct 2014, Abano Terme (PD-Italy)

The effects of neuromuscular training on vertical jump in young female basketball players

Roberto Benis, Antonio La Torre.

Department of Biomedical Science for Health, Università degli Studi di Milano, Milan Italy

Aim of this study is to measure the influence of neuromuscular training program on vertical jumps in female young basketball players. Fifty-five healthy regional female basketball players (17±2 y-o; 62.9±8.4 kg; 174±7 cm; 20.8±3.1 kg/m^2) were involved in a 9-wks protocol consisting of 3 session/week of 2 hour of basketball practices. All subjects were divided in two groups: 30 in the "experimental group" and 25 in a "control group". The 20 min neuromuscular program consisted in core endurance, plyometrics and strength exercises whereas the control group performed the normal training routine. Subjects were tested at baseline (BL) and week 9 (W9) by Counter Movement Jump (CMJ) and one legged CMJ (Optojump, Microgate, Bolzano, Italy). No significant differences were found at BL in the two groups. At W9, experimental group showed significant improvements in CMJ (ES 0.8) one-legged CMJ right leg (ES 0.8) CMJ left leg (ES 0.6). Regarding the control group we didn't find any significant differences at W9 compared to BL. The study shows how a neuromuscular training program has shown to increase vertical jumps in young female basketball players.

References

1. Anderst,DM. et al. (1994) Med Sci Sports Exerc 26: S31,

2. Hewett TE et al. (2006). Am J Sports Med.: 34:490–498

3.Zazulak BT et al. (2007). Am J Sports Med. 35:1123–113

4.Gal Ziv et al . (2010) 13: 332–339

6rd National Congress at Scuola Italiana delle Scienze Motorie e Sportive , 26th – 28 th sept 2014, Napoli (Italy).

The effects of strengthening exercises on the hip abduction musculature in professional female basketball players

Authorship:R. Rossi, R.Benis, A.La Torre

Department of Biomedical Science for Health, Università degli Studi di Milano, Milan Italy

Aim:

Rapid acceleration and landing after the jump, typical of basketball game, are identified as mechanisms of acute injury to the knee (Devita et al 1992).The role of muscle strength of the hip according to the authors has a relationship with the injuries prevention.(Niemuth et al 2005).The aim of this study is evaluate the influence of exercise program on hip abduction strength in female basketball players.

Methods:

Forty-one professional female basketball players **(**24,6±3 y-o; 70.9±7.4 kg; 178.6±6.8 cm; 22.3±1.7 kg/m^2) were involved in a 6-wks protocol consisting of 3 session/week with 4 exercises in according with Selkowitz et al. All subjects were divided in two groups: 22 in the “experimental group” and 19 in a “control group” that performed the normal training routine of physical and technical basketball drills.

Subjects were tested at baseline (BL) and at week 6 (W6). Hip abduction muscles strength is measured with a handheld dynamometer (Lafayette Inst.) The test were in sidelying position and selected based on their similarity to traditional manual muscle testing procedures in according to Kendall et al.

Results:

All participants completed the 6 weeks program, A paired T-test and a unpaired T-test were used respectively to assess pre-post differences within groups and between groups. Results were expressed as mean ± SD. Significant differences were found at $p<0.05$

The experimental group at W6 showed significant improvements in hip abduction strength, in right (ES0,6) and left (ES0,4) limbs, calculate in term of torque (strength = ((MMT reading in netwons)*distance/bodyweight in kilograms. The control group did not show any significant difference at W6 compared to BL. Significant difference between groups with unpaired t-test.

Conclusions:

The study shows how, by a simple and short program of exercising to strengthen the hip muscles that control how hip moves has a significant influence on the hip abduction strength in professional female basketball players.

References

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Niemuth et al Clinical journal of sport medicine. (2005) Vol 15 –issue 1 pag 14-21
Devita et al. American college of sport medicine. (1992) Vol 24 –issue 1

The effects of neuromuscular training on upper body strength in young students

Authorship: R.Benis[1], M.Roncelli[1], La Torre[1]

1 Department of Biomedical Science for Health Physical Education at the University of Milan

Aim:

Aim of this study is measure the influence of neuromuscular program on the upper body's strenght in the young student of secondary school .

Methods:

One-hundred twenty-four students of secondary school ITG.S Giacomo Quarenghi of Bergamo (16±2 y-o; 62.9±8.4 kg; 174±7 cm; 20.8±3.1 kg/m^2) were enrolled in a 9-wks protocol consisting of 2 sessions/week of 1 hour of physical education. All subjects were divided in two groups: 79 in the "experimental group" and 68 in a "control" group. The neuromuscular program of 15 min consisted in core endurance, plyometrics and strength exercises with use of body weight, whereas the control group did the normal plane of lessons of physical education. The program provides trunk and lower limbs activity, without exercise for upper limbs.

Subjects were tested at baseline (BL) and week 9 (W9) by when upper body strength strength is measured with a hand grip dynamometer. Differences over time were assessed with paired T-test and differences between groups with unpaired t-test. Results were expressed as mean ±SD. Significant differences were found $p<0.05$.

Results:

All participants completed the 9 weeks program with a mean adherence of 90%. No significant differences were found at BL in the two groups.

The experimental group at W9, showed significant improvements in hand grip test with dominant hand. Regarding the control group we didn't find any significant differences at W9 compared to BL

Conclusions:

These results shows that isometric strength of the upper limbs in young students is significantly increased by using neuromuscular training program.

References

Sartorio A. et al. (2002) The impact of gender, body dimension and body composition on handgrip strength in healthy children. *J. Endocrinol. Invest.* 25:431–435.

Massy-Westropp et al.: (2011) Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Research Notes* 4:127.

Griffin LY, et al.(2005) Noncontact anterior cruciate ligament Injuries: risk factors and prevention strategies. *J Am Acad Orthop Surg 2;8:141-150.*

Influences of basketball practice in maximal ankle dorsiflexion range of motion

Authorship:R.Benis[1], A.La Torre[1]

Department of Biomedical Science for Health, Università degli Studi di Milano, Milan Italy

Aim

In professional basketball teams the importance in the management of the athlete is the part used to evaluate the performance and the prevention of injuries. The ankle mobility of the ankle joint is important in the athlete's lower kinematics and muscle activation. In fact restrict ankle dorsiflexion during dynamic tasks have been reported in individuals with patellofemoral pain (PFP) and are theorized to play a role in its development (Macrum et al 2012). Strength and conditioning coaches and physiotherapist measure and evaluate the ankle functionality with different tests. The aim of this study is to monitor the influence of basketball practice in the maximal ankle dorsiflexion range of motion in female basketball players during the season .

Method

Thirty-eight professional female basketball players of the Italian league **(**25,6±3 y-o; 73.9±7.7 kg; 181.6±6.8 cm; 22.1±2.1 kg/m^2) were monitored in the pre-season 2013 and 2014. Participants performed the weight-bearing lunge test (WBLT) to assess their maximal ankle dorsiflexion range of motion ROM, based on the Vicenzino et al (2006) study. Each subject performed the following protocol: 5' warm-up with jogging and two trials test for side.

All measures were obtained three times per side; the score result is the best measure of distance to wall.All participants completed the competitive season without severe injuries in lowers limbs.

Differences over time were assessed with paired T-test and ES. Results were expressed as mean ±SD. Significant differences were found $p<0.05$.

Results

We have found by the statistical analysis with paired T-test there isn't significant difference in dorsiflexion range of motion ROM between may 2013 versus may 2014, but with further analysis the date produced following numbers: in right leg (ES 0,5) and left leg (ES 0,6). The effect size show we reduced of Rom in ankle dorsiflexion in female athletes after the basketball season.

Conclusion

In this research we note that basketball practice in season has a negative influence in dorsiflexion ROM ankle mobility in female athletes.. Due to the important of lower limbs efficiency in basketball sport is useful for players and staff monitoring the joints for prevention injuries and performance, especially in basketball technical fundamentals as defensive slide and jumping the ankle functionality is important.

References:

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3.Hoch M et al. (2011) Dorsiflexion range of motion signifycantly influences dynamic balance. J Sci Med Sport. ;14:90-92
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5. Vicenzino B et al. (2006) Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. J Orthop Sports Phys Ther.;36(7):464-471

7rd National Congress at Scuola Italiana delle Scienze Motorie e Sportive , 2th Oct– 4st Oct 2015, Padova (Italia)

The Scouting project of the Italian Basketball Federation for female talent selection

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[1] *Department of Movement, Human and Health Science, University of Rome "Foro Italico"*

[2] *Department of Biomedical Science for Health Physical Education at the University of Milan*

[3] *Italian Basketball Federation*

Aim:

Since the early 2000s, the scouting project "Centri Tecnici Federali" (CTF) has represented the largest program for female talent selection of the Italian Basketball Federation, Federazione Italiana Pallacanestro (FIP). The aim of this study was to measure the influence of CTF on players' selection for the Italian National team between 2007 and 2014.

Methods:

For this study, 1517 athletes born between 1992 and 2001 were selected. A longitudinal analysis was carried out on their national and international careers, starting with information collected during the CTF scouting (14.39±0.55 y-o). The data was analyzed based on: age, height, duration of CTF selection, duration of transition period between CTF and professional career (PRO), and number of seasons spent in the national championship. Differences between groups were assessed with Chi Square and Student T-test (significant differences were found P<0,05). Results were expressed as percentages, means and SD.

Results:

The results show that 50% of the athletes reached a national level (NL) championship and 6% reached an international level (IL). Significant differences emerged for every parameter, except for the duration of transition period between CTF and PRO. It is also interesting to note that 90% of the players U22 recruited on the national team in the summer of 2014 have had previous experience with CTF scouting.

Conclusion:

Beyond strong physical development (1), our study shows how other factors, such as the relevant social context or how old the athlete was when she was scouted, can have a significant effect on the development of a talented athlete (2). In conclusion, our results confirm the importance of CTF for Italian female basketball players for their national and international career.

References:

1) Erčulj F, Bračič M (2010) "Differences between various types of elite young female basketball players in terms of their morphological charateristics", Kinesiologia Slovenica, 16, 1-2, 51-60.

2) Vaeyens R, Güllich A, Warr CR, Philippaerts R (2009) "Talent identification and promotion programmes of Olympic athletes", J Sports Sci, 27:13, 1367-1380.

Title:**Hand grip strength and anthropometric characteristics in Italian female National basketball team**

R.Benis[1], Margherita Micheletti Cremasco[3] Luisa Pizzigalli[2], Antonio La Torre[3] A.La Torre[1]

[1]Department of Biomedical Sciences for Health-University of Milano

[2]MotorScience Research Centre-Department of Medical Science-University of Torino

[3]Department of Life Sciences and Systems Biology-University of Torino

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Aim:

The aim was to investigate if there is an influence of the hand dimensions on hand grip strength, if they are related to body dimensions and to define a reference scale for talent identification

Methods:

Female Italian basketball national players (109 subjects Under14-Seniors) were examined about anthropometric and hand strength characteristics**,**We measured body mass, height, hand length and breadth (ISO7250-1- 2008), maximum hand spread (five fingers' span) (Peebles and Norris, 1998- Visnapu and Jurimae, 2007), maximal handgrip strength (Mathiowetz et al.,1985, by Jamar Hydraulic Hand dynamometer).

Results:

Handgrip strength trend increase, as well as age/sport level, raising the statistical significant difference only after 19 years aged players respect to younger, and for dominant (right) hand only in Seniors. It's possible that higher values and asymmetry were induced by strength training. No differences were showed for hand length as expected, but neither for breadth anatomical measures nor for functional dimension as hand span. Furthermore, comparing stature and hand length with not athletes Italian adult females (Masali, 2013; Fubini et al., 2011), the national basketball athletes values are near the highest percentiles, but not the hand length. Moreover, body dimensions show low correlations values with handgrip strength.

Conclusion:

We concluded that anthropometric selection in basketball players, generally based on stature values already in young athletes, select indirectly also by hand length, but not by breadth and span, and least of all by handgrip strength. We suggest to consider hand grip strength to aid talent identification at a young age and to increase it by training.

Proposal of an alternative method to find out the "break-point" in Nordic Hamstring Exercise: a pilot study

L. Russo[1], M. Tentarelli[2], L. Barni[3], M. Tentarelli[3], R. Benis[4], M. Sacchetti[5], A. D'Ovidio[6], P. Bartolucci[1], J. Padulo[7]

[1]*Department of Applied and Clinical Science and Biotechnology, University of L'Aquila, Italy*

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[4] *Department of Biomedical Science for Health Physical Education at the University of Milan, Italy*

[5] *Department of Sport, Human and Health Science, University of "Foro Italico", Rome, Italy*

[6] *Sport Science Master degree*

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Aim: Nordic Hamstring Exercise (NHE) is a well known exercise used to eccentrically train the hamstring muscles. Sometimes it is also used as a test for injury prevention but the measurement modalities are poor[1,2]. This study proposes an alternative method to measure the "break-point" (BK) during the NHE movement.

Method: Twelve female young national basketball players (16±0 yrs; 176±7.8 cm; 67.9±9.9 kg) were filmed at 30fps (Casio FH20, Shibuva, Tokyo, Japan) during a NHE training session. Each subject performed three NHE and the best was chosen for the analysis. Three static markers were applied on the lateral malleolus, lateral knee and trochanter of the right leg for the video analysis (Dartfish 6.0, Fribourg, Switzeland). For each NHE it was measured the dynamic posterior angle of the knee and it was exported and analyzed with a time/angle diagram. The data were elaborated with an algorithm to find out the BK in which the subjects lost the control of the exercise falling frontward.

Results: The average time of the NHE was 2.3±0.5s, the BK arrived at 69% of the movement after 1.6±0.5s. The average BK arrived after 17.3±2.8° of movement although the 58% of the subjects maintained a correct alignment after 30° of movement.

Conclusion: The used algorithm allows to discriminate the dynamic BK starting from the posterior angle of the knee. These results avoid the observation process used in other evaluation protocols of the NHE[1,2]. Further studies on the algorithm and its validity are needed.

References

1. Engebretsen AH et al. (2010). Am J Sports Med 38(6):1147-53.
2. Sconce E (2015). J Sport Rehabil 24(1):13-20.

Effects of whole-body cryotherapy on sit and reach amplitude in healthy women

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[2] Department of Biomedical Sciences for Health , University of Milano, Milano, Italy

Aim: A decrease in neural activation of the muscle has been linked with greater range of motion (ROM). The application of cold agents could reduce neural activation. Whole-body cryotherapy (WBC) consists in the exposure of the human body to a very cold temperature (minor than -110°C) for a short period of time. The aim of the present study was to evaluate if both a single session and ten sessions of WBC affect ROM.

Methods: 90 women were recruited for this study. They were divided into two groups (control and experimental). After the initial sit-and-reach test, experimental group performed a 150 s session of

WBC, whereas the control group performed the same movements (standing rotation) in a temperature-controlled room. Immediately after, both groups performed another sit-and-reach test. 30 of these subjects were also divided into other two subgroups: experimental performed ten 150 s sessions of WBC and immediately before and after the tenth session they performed another sit-and-reach test; control performed another sit-and-reach at the tenth day of the study.

Results: Experimental groups improved sit-and-reach amplitude to a greater extend than the control group, both after one single WBC session than after ten consecutive WBC sessions.

Conclusions: Our results support the hypothesis that ROM is increased immediately after a single session of WBC. This increase remains also after ten consecutive WBC sessions.

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C.C. Larsen, J.M. Troiano, R.J. Ramirez, M.G. Miller, W.R. Holcomb, Effects of Crushed Ice and Wetted Ice on Hamstring Flexibility After PNF Stretching., J. Strength Cond. Res. (2013).

A.A. Algafly, K.P. George, The effect of cryotherapy on nerve conduction velocity, pain threshold and pain tolerance., Br. J. Sports Med. 41 (2007) 365–9; discussion 369.

Appendices

Attached

Individual Injury Report Form (Chapter two-study one)

Federazione Italiana Pallacanestro Settore Squadre Nazionali Femminili

QUESTIONARIO SU INFORTUNI LCA

SQUADRA: ___________________________ **LIVELLO :** A1 A2

ATLETA: ____________________________

ANTROPOMETRIE:
- Altezza __________________
- Peso corporeo ____________

RUOLO
- Guardia
- Ala
- Centro

ETA' AL MOMENTO DELL'INFORTUNIO
- _________

PERIODO AGONISTICO AL MOMENTO DELL'INFORTUNIO:

- Pre season
- Girone di andata
- Girone di ritorno
- Playoff/Playout
- Off season
- Attività con squadre nazionali

INFORTUNIO OCCORSO DURANTE:

Allenamento
- Parte iniziale
- Metà
- Parte finale

Game
- Warm-up
- 1° quarto
- 2° quarto
- 3° quarto
- 4° quarto

MODALITÀ DI INFORTUNIO
- Con contatto

- Senza contatto

MOVIMENTO CESTISTICO

- Cambio di direzione
- Atterraggio da un salto
- Arresto
- Altro_________________

I.B.I.P.P. (Italian Basket Injury Prevention Program) (Chapter four -study III)

Il riscaldamento prepara gradualmente l'organismo per l'esercizio intenso ed è particolarmente importante perché il corpo funziona in modo più efficiente quando la sua temperatura interna è superiore a quella di riposo. Per questa ragione IBIPP inizia con un breve periodo di corsa che può essere fatto anche con la palla, l'inserimento dell'attrezzo pallone ha lo scopo di rendere più divertente la fase iniziale introducendo esercizi che stimolino il controllo e il ball-handling a patto di rispettare i criteri di progressività e bassa intensità di spostamento che la prima parte del riscaldamento prevede.

Dopo la fase di corsa sono stati inseriti alcuni esercizi di stretching, esercizi di forza, pliometria controllo senso motorio e propiocettività. L'obiettivo principale della fase di warm-up è di preparare l'organismo a svolgere le attività successive. Molti degli esercizi proposti all'interno di IBIPP sono stimolanti, ma non eccessivamente intensi. Ogni esercizio successivo è realizzato con un'intensità progressivamente crescente, portando l'atleta vicino ai livelli delle esercitazioni di allenamento vere e proprie.

I.B.I.P.P. è suddiviso in 5 fasi:

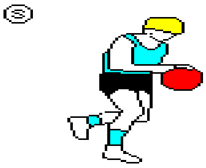
1à- Fase attivazione con corsa. Durata di 2-3'
2à. Fase di mobilità articolare con 3-5 esercizi per circa di stretching dinamico da 1-2 serie x 10 ripetizioni. Durata 3'
3à- Fase di potenziamento muscolare con 3-4 esercizi da 6-12 ripetizioni per 2 serie . Durata 5'
4à -Fase pliometrica con 3 esercizi da 10-12 ripetizioni per 2 serie. Durata 5'
5à- Fase di agilità con 3 esercizi per 2-3 serie che possono essere se svolti in continuità con la palla. Durata 3-4'

Il tempo previsto per lo svolgimento del programma è circa 20-22'. A seconda del numero di serie proposte, dei soggetti e se le esercitazioni vendono proposte o meno a circuito. La soluzione ideale è il lavoro in coppia in modo che l'allievo che non lavora posso fare assistenza o correzione.
Il protocollo ridotto prevede la riduzione del numero degli esercizio di forza e di pliometra e l'utilizzo di solo 2 esercizi di agilità e destrezza.

1à Fase: Attivazione

Sul campo da basket (lavoro a tempo o determinando i campi)

1. corsa avanti-indietro 1'
2. corsa con avanti con virate 1'
3. corsa laterale e incrociata 1' questi esercizi possono essere fatti con la palla



2à Fase : Mobilità articolare

Gli esercizi prevedono l'utilizzo dello stretching dinamico:

1-Oscillazioni degli arti inferiori Piano frontale-sagittale con mani in appoggio al muro slnciare gli arti inferiori sul piano sagittale , seguite poi da slanci frontali .

Volume: 1 serie per 10 ripetizioni per esercizio

2- Stretching del quadricipite: Flettere il ginocchio per portare il tallone verso il sedere, alternare gli arti alternandoli durante il cammino

Volume: 1serie per 10 ripetizioni o per metà campo da basket

3)- Flessori dell'anca in affondo:Effettuare un ampio passo lungo verso avanti , portare le mani verso l'interno della gamba che è avanti, fino a che il gomito sfiora il terreno, tenere la posizione 2 -3" e ritorno ,

Volume: 1 serie per 10 ripetizioni o per metà campo da basket

4) Passo laterale con incrocio: Camminata laterale incrociando e piegando le gambe,

Volume: 1 serie per 10 ripetizioni o per metà campo da basket

4) Inverted hamstring
Da in piedi effettuare un passo indietro e mantenendo l'arto inferiore il ginocchio lievemente piegato e fisso inclinare il busto avanti, portando aprendo gli arti superiori in fuori, mantenere la posizione per 2” e ritornare in posizione eretta.

Volume 1-2 serie per 10 ripetizioni

4-Piegate laterali: In divaricata frontale, andare in piegata sulla gamba di appoggio con il busto eretto o lievemente flesso in avanti   posizione da tenere 2” , poi ripetere dall’altro lato.

Volume: 1 serie per 10 ripetizioni o per metà campo da basket

3à Fase: Potenziamento muscolare a stabilità:

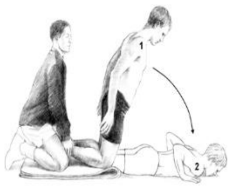
1- Side bridge: Sollevare il bacino e la gamba superiore fino a formare una linea retta con la spalla e mantenere la posizione . Il gomito del braccio d’appoggio è posizionato verticalmente sotto la spalla. Mantenere il corretto allineamento del corpo durante l’esercizio**,**

Volume: 2 serie per 20-40” o 10 ripetizioni per lato

2-Affondi : Fare un ampio passo avanti lungo e piegare l’arto inferiore anteriore e posteriore, risalire ripetere con l’altro arto.

Volume: 2-3 serie x 12 ripetizioni

2- Nordic hamstring: Un compagno fissa i piedi di chi esegue, che si lascia cadere verso avanti ; ritardare la caduta in basso senza flettere il busto sulle anche in anticipo e ammortizzare al caduta usando gli arti superiori.



Volume: 1 serie per 6-8 ripetizioni

3- Flesso estensioni del piede: In stazione eretta (monopodalico) con mani in appoggio , Posizionarsi su un gradino (soluzione ideale) o al suolo , sollevarsi su un piede

Volume: 2 serie x 15 ripetizioni

4à fase : Pliometria

1 -Salto verticale: Saltare verso l’alto con ricaduta in posizione semi-piegata

Volume: 1-2 serie da 10 ripetizioni

2 -Salti frontali : saltare oltre il cono o le strisce posizionate 30 cm avanti

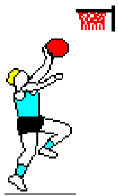
Volume: 2 serie 10 ripetizioni

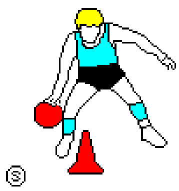
3- Salti laterali: Saltare lateralmente i coni –ostacoletti.

Volume 2 serie per 10 ripetizioni.

5à Fase : Agilità e destrezza (con uso della palla)

1) Navetta: corse avanti e indietro e laterali con cambi di senso e direzione
2) Partenze in palleggio e arresti ai conetti
3) Palleggio con entrata a canestro
4) Corsa con percorso e tiro da fuori





Volume: 3-4 ripetizioni per esercizio su metà campo.

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Box 1
Note esecutive pratiche

1-Ogni fase deve essere supervisionata, correggendo e facendo attenzione ad elementi specifici come le spinte corrette degli arti inferiori nei cambi di direzione e il loro allineamento durante la ricaduta dai salti o le frenate.
2-La forma metodologico-organizzativa migliore è il circuito con gli allievi in coppia, in modo da avere regolare tempo di recupero e assistenza esecutiva durante l'esecuzione.
3-Passare nelle fasi successive ad esercizi di salto che prevedano partenze o arrivi su 1 solo arto.

4-Nei salti controllare che l’allievo ammortizzi la ricaduta flettendo le anche e le ginocchia e eviti di portare le ginocchia verso l’interno (ginocchio valgo).
5-Sugli affondi, insegnate agli allievi ad auto correggersi, se non vedono il loro piede in avanti, stanno eseguendo l’esercizio in maniera scorretta.
6-L’esercizio nordic hamstring va fatto scendendo lentamente e mantenendo l’allineamento del bacino-tronco.
7-Rimanere piegati sulle gambe durante gli esercizi che prevedono virate o cambi di velocità o direzione.

Box 2

Linee guida esecutive per gli esercizi di stretching dinamico:

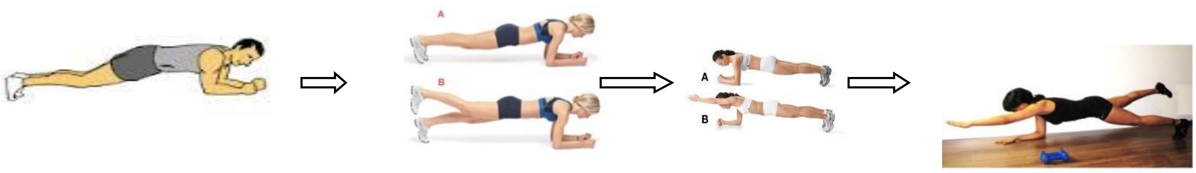
1-Alcuni esercizi prevedono movimenti veloci di slancio (ma sempre a velocità controllata) e altri dove la posizione viene tenuta per 2” senza eseguite molleggi. Il numero di ripetizioni è 10 oppure tante quante ne servono per compiere metà campo di pallacanestro.
2-Aumentare progressivamente l’escursione del movimento articolare ad ogni ripetizione in particolare nella serie iniziale.
3-Aumentare la velocità di movimento nelle serie successive, se previste e dove e possibile farlo non abbandonando una buona tecnica esecutiva.

Esercizi addizionali e o sostitutivi

(Da effettuare prima o a fine seduta per implementare il lavoro oppure in sostituzione di altri esercizi per variare la proposta)

Giorno 1

Panchina prona (plank) 4 appoggi e passare poi a 3 e a 2 appoggi con elevazione-abbassamento alternato degli arti inferiori/superiori 2 serie da 30” fino a 50”



Standing reaches: Mantenendo l’equilibrio su 1 piede piegarsi piegare l’arto inferiore e flettere il busto in avanti fino in avanti a toccare i coni .

- Effettuare 1-2 serie da 9 toccate (3 per lato),,
- Possibile la variante utilizzando il piede libero per toccare i conetti

Bulgarian split squat . in appoggio su 1 arto inferiore e l’altro in appoggio su una panca, effettuare delle piegamenti sulle gamba . 1-2 serie x 12 rps (6+6) a.

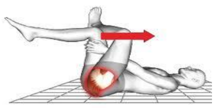
<u>Salti ginocchia la petto</u>   1-2 serie x 15 sec

Importante il controllo della esecuzione , in particolare sul posizionamento delle ginocchia al ritorno al suolo.

b.

<u>5.Stretching</u> dei muscoli gluteI e   piriforme/catena laterale anca e tronco da eseguire   da supino con 2 esercizi x 1-2 serie da 30”.

1° da supino , gambe incrociate, portare un ginocchi al petto (vedi foto)
2° da supino, spalla al suolo portare il ginocchio verso il pavimento della parte opposta.



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Giorno 2

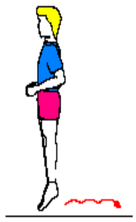
<u>1.Superserie</u> Crunch addominale +   estensioni opposte arto superiore-arto inferiore   “superman” con 3+3 serie x 20 rps.

Note esecutive: Eseguire le ripetizioni con una velocità lenta, controllando il movimento in particolare nell’esercizio superman.

+

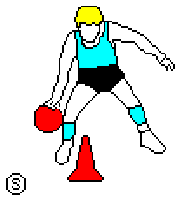
<u>2.Semipiegamenti su 1 gamba</u> , mani a i fianchi o libere , tallone al suolo per   1-2 serie da 5-8 rps x gamba
Importante l’esecuzione lenta di ogni ripetizione che dovrebbe avere un ritmo di almeno 3” nella discesa,2”di sosta in posizione di semi-piegamento e 3” nella salita.

3.Saltelli piedi pari in avanzamento 1-2 serie da 20 sec” o da 20 toccate (mantenere le ginocchia leggermente “sbloccate”).

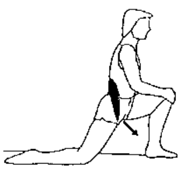
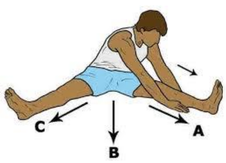
4.Corsa con cambi di direzione ai coni e arresti in posizione fondamentale su 1 piede per 2” effettuare almeno 6 arresti per piede x 2 serie

Note esecutive: prestare attenzione negli arresti , in particolare sulla posizione del ginocchio del tronco.



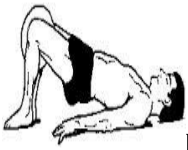
5.stretching per muscoli flessori anca e adduttori:

Con un ginocchio poggiato sul tappetino e l’altra gamba divaricata frontalmente, (attenzione a mantenere il ginocchio sulla proiezione del piede!!) s poggiare le mani al suolo e sul ginocchio con busto eretto e lo sguardo avanti.
Tenere la posizione per 20” per lato.
Da seduto a gambe divaricate, inclinare il busto in avanti verso la gamba sx (a) poi verso il centro (b) e infine verso la gamba dx (c) tenere ogni singola posizione 10” per un totale di 30”

 + 

Giorno 3

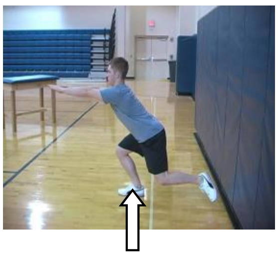
1.Bridge : Da supino, elevazione del bacino verso l'alto tenendo un pallone tra le ginocchia 2 serie x20 reps

 passare poi ad eseguire l'esercizio con un solo piede 

2. Equilibrio su 1 piede, spostare la palla da basket o una palla medica a dx-sx mantenendo l'equilibrio e la posizione iniziale . 2 serie x 20 rps (10 per lato)

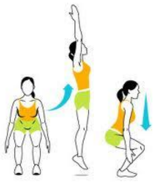
3. Squat isometrico: Piegarsi sulle gambe e fissare la posizione 2 – 3 serie iniziare con 10" per arrivare a 25-30"

Importante la posizione delle ginocchia che devono "spingere" in fuori con la rotula sulla direzione del 2° dito del piede e con la proiezione del ginocchio che non deve oltrepassare le punte dei piedi.



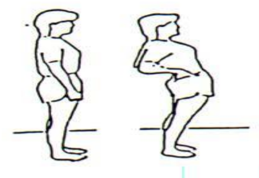
passare in seguito poi alla tenuta della posizione su 1 sola gamba 2 serie iniziare con 10" per arrivare a 20"

4.Salti con giro 90° da posizione di mezzo squat, compiere un salto verso l'alto, giro e ritorno al suolo nella posizione a gambe semipiegate della partenza. 1-2 serie x 5-8 rps.



5.Corsa laterale a navetta andata e ritorno sui 5 metri alternando l'esecuzione rapida a quella lenta (rispettando la posizione difensiva)   6 serie con 20 " recupero

Importante
Il protocollo di lavoro presentato è una proposta di lavoro generale, che non può andare incontro alle esigenze specifiche della singola giocatrice ed è pensato senza utilizzo di attrezzi.
Si consiglia di effettuare nei 10' precedenti l'allenamento esercizi di mobilità articolare, di propriocezione , core control ecc… anche con attrezzi specifici



Scheda compilativa sugli infortuni (Chapter four-study III)

Prego riporta tutti gli infortuni, causati dalla pratica della pallacanestro

Atleta:

- Età:
- Altezza:
- Peso:
- Ruolo:
- Infortunio avvenuto in partita:
- Infortunio avvenuto in allenamento:
- Data:

Circostanza dell'infortunio : Contatto Non contatto
Giorno di assenza dall'allenamento:

P.S. Per infortunio consideriamo l'assenza dall'allenamento tecnico o dalla partita.

<u>Parte anatomica che ha subito l'infortunio</u>

Testa e tronco
Capo
Collo
Rachide Dorsale
coste
Rachide lombare
Pelvi
sacro

Arti superiori
Spalla
Gomito
Polso
dita

Arti inferiori
Anca
Bacino
Coscia
Ginocchio
Caviglia
Piede
Dita

L' <u>informazione fornita è con scopo di ricerca è sarà trattata confidenzialmente.</u>
<u>Scheda numero…………….</u>

Esempio di scheda per raccolta dati

team		mese										
………		……	settimana 1	partite	settimana 2	partite	settimana 3	partite	settimana 4	partite	totale minuti	
	Nome	Cognome	minuti x settimana		minuti x settimana		minuti x settimana		minuti x settimana			
1	C.	A.	360	1	360	1	360	1	360	1	1444	
2	F.	L.	360	1	360	1	360	1	240	0	1323	
											2767	tot.minuti
												squadra

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