



THE EPIDEMIOLOGY AND PREVENTION OF INJURIES IN CONTACT FLAG FOOTBALL

Yonatan Kaplan



Thesis submitted
in fulfillment of
the requirements
for the degree of
Doctor in Motor
Rehabilitation and
Physiotherapy





Faculty of Medicine and Health Sciences

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Who is honored? The one who gives honor to others...
Who is wise? The one who learns from every person...
(Talmud - Avot 4:1)

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This original injury prevention research endeavour commenced during the contact flag football season in 2005. The management of the American Flag Football league in Israel requested assistance in treating the injuries in the national team. I attended numerous game and practice sessions and witnessed firsthand the type, nature and mechanism of injuries in this fast growing sporting activity. My interest was sparked and I approached the management of the league and requested permission to embark on a two-season epidemiological study. I started working with an incredible set of devoted personnel, who, from the outset, have contributed their time, patience and experience over the past seven years. This list includes first and foremost Mr Steve Liebowitz, the founder and President of the Israeli Flag Football League (AFI), who first introduced me to this sport, Mr Danny Gewirtz, the first commissioner, Mr Adam Slater, the current commissioner and league administrator, Mr Dovi Rabinowitz, Director of Officiating, Miss Shana Sprung, administrator of the women's league, and Mr Simon Pack, head of the computer division.

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"I have learned much wisdom from my teachers, more from my colleagues and the most from my students" (*Babylonion Talmud, Ta'anit 7a*)

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Yonatan Kaplan, Ghent,

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CHAPTER 1

GENERAL INTRODUCTION

"Two elements are crucial. One must have an insight into which problems are ripe for resolution, and one must then have the craft - or invent it- to solve the problem one has the audacity to recognize as solvable"

- Palle Yourgrau

Sport is considered a vital component of an active and healthy lifestyle, reducing the risk of various diseases and contributing to better social and physical performance. The beneficial effects of playing sports must be balanced against injuries that are to some extent inevitable¹ and a detrimental consequence and an important public health problem², especially in contact sport.³ Treating sports injuries is often difficult, expensive and time consuming, and thus, preventive strategies and activities are justified on medical as well as economic grounds.⁴

It is now understood that sports injury interventions will not have significant public health impact if they are not widely accepted and adopted by target sports participants. A major reason for this is that there are significant challenges in conducting implementation research. In the more traditional sports medicine approaches, real-world implementation of sports injury interventions and evaluation of their effectiveness do not take into account the broad ecological context, i.e. how it can be promoted in such a way as to not contradict the accepted culture. Better ways need to be explored in order to translate this knowledge to reach the audiences who most need to benefit from such research. Although there has been increasing recognition of the need for intervention studies conducted within the real-world context of sports delivery, very few studies have been conducted in this important area. Having stated this, several studies, mainly dealing with the prevention of musculoskeletal injuries in soccer and handball, have documented that injuries can be prevented if programme compliance is sufficient.^{5,6,7,8}

A successful injury surveillance and prevention programme requires valid pre- and post-intervention data on the extent of the problem. The etiology, risk factors and exact mechanisms of injuries need to be identified before initiating a measure or programme for preventing sports injuries, and measurement of the outcome (injury) must include a standardized definition of the injury and its

severity, as well as a systematic method of collecting the information.⁹ Valid and reliable measurement of the exposure includes exact information about the population at risk and exposure time.

Arguably, the most commonly cited model of sports injury prevention over the past two decades has been that initially articulated by van Mechelen and his colleagues in 1992¹⁰, which briefly consisted of four steps. Firstly the extent of the sports injury problem must be identified and described. Secondly the factors and mechanisms which play a part in the occurrence of sports injuries have to be identified. The third step is to introduce measures that are likely to reduce the future risk and/or severity of sports injuries. This measure should be based on the etiological factors and the mechanism as identified in the second step. Finally the effect of the measures must be evaluated by repeating the first step. The most serious limitation of the van Mechelen et al. model is that it does not consider the need for research into implementation issues, once prevention measures have been proven effective.¹¹

A more recent research framework model ("Translating Research into Injury Prevention Practice framework", or "TRIPP"¹¹, has been described that emphasizes the fact that only research that can, and will, be adopted by sports participants, their coaches and sporting bodies, will prevent injuries. It is a concerning assessment of much sports injury research endeavour, that very few studies actually talk about intervention uptake issues in the presentation of their findings. The TRIPP framework

(Figure 1.) recognizes that a complete evidence base for prevention requires:

- (a) a detailed understanding of the etiology of injuries;
- (b) development of interventions to directly address the identified mechanisms of injury;
- (c) formal testing of these interventions under controlled conditions (i.e., efficacy research);

- (d) understanding of the sporting and individual athlete behaviours context in which the interventions are to be implemented;
- (e) potential modification of interventions to take this implementation context into account;
- (f) assessment of potential factors associated with the real-world introduction and application of safety measures and development of implementation strategies to accompany the real world ‘roll-out’ of the interventions; and
- (g) formal evaluation of the effect of injury prevention measures within the implementation context.¹¹

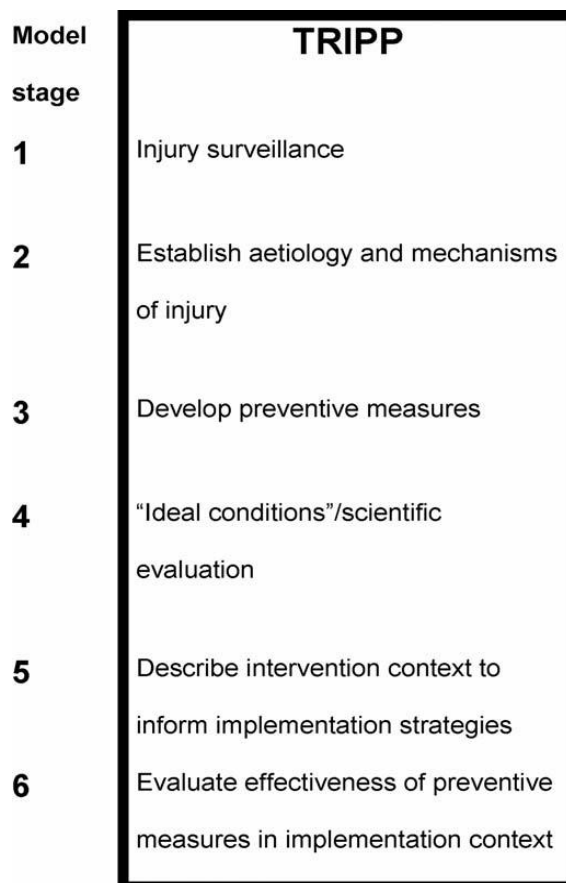


Figure 1. The TRIPP framework

Recent ideas on injury prevention that call for studies on real-life injury prevention still rely heavily on preventive measures that are established through efficacy research. A serious limitation in such an approach is that one expects that proven preventive measures will be adopted if the determinants and influences of sports safety behaviours are understood.¹² One of the main long term goals of any prevention study should therefore focus on how the outcomes of the efficacy research can be translated into actions that can be actually implemented in the real-world context of on-field sports behaviours.⁹ This must be implemented first and foremost on a local sporting level. With experience and positive results gained, these methods can be implemented on a national and international level. This topic has become the focus of many of the recent sports medicine injury prevention conferences. Literature is being constantly published about the great need to translate the myriad of epidemiological and prevention studies already published, into the real world context.^{13,14,15,16} Sports bodies will not implement sports safety policies until they are sure that the safety measures actually prevent injuries, are acceptable to their participants, do not change the essential nature or appeal of the sport, do not adversely affect participation or performance and safety is a major motivator for their core business (i.e., either to perform better or to increase participation numbers).^{17,18} If the athletes, coaches or sports administrators we are working with will not use or adopt any of the prevention measures that we advocate, then all of our preventive efforts will fail. Future advances in sports injury prevention will only be achieved if research efforts are directed towards understanding the implementation context for injury prevention, as well as continuing to build the evidence base for their efficacy and effectiveness of interventions.¹⁵

Implementation is about behavioural change. Applications of behavioural science to injury prevention lagged behind other approaches during the last half of the 20th century. Despite recognition by injury control professionals of the importance of behavioural research in injury prevention, behavioural solutions to preventing injury were de-emphasized.^{19,20} A growing body of work is emerging that demonstrates the positive impact of using behavioural approaches in order to both understand and reduce injury risk behaviours.^{21,22} Different types of behaviour relate to injury risk factors and injury mechanisms.¹² Behaviour that influences risk factors and injury mechanisms is not confined only to the athlete. Multiple behaviours often act together. Some types of behaviour may directly affect injury risk and are by definition a risk factor. Other behaviours may only affect risk factors and injury mechanisms, and influence injury risk indirectly. Therefore, if one truly wants to prevent sports injuries in a real-life situation, a broader research focus is needed.¹²

Before designing wide-scale implementation of preventative measures it is also necessary to know how likely it is that the developed interventions will be adopted. There is no doubt that intervention research in the field can be difficult and many challenges need to be overcome, however, that should not be a barrier towards undertaking it. Players and sporting clubs will more likely participate in intervention research if they are fully informed about the study and the intervention being trialed. In a trial involving Australian squash players²³, the authors concluded that their protective eyewear promotion (PEP) project, which was based on educating players about the need for PEP, was successful in that players exposed to PEP, changed their behaviour, and the sales of eyewear and their usage during the trial increased significantly. In a second study²⁴, Australian football players were questioned about personal protective equipment (PPE). The authors' conclusion was that although it seems that there are fairly consistent reasons for PPE use, perhaps further education of players, coaches, and support staff into the importance of PPE is warranted to increase equipment

compliance and general usage. This is based on attitudes towards PPE which can have an influential effect on the actual use of the equipment. Wearing protective equipment is a type of behaviour, and players' attitudes towards protective equipment will influence their behavioural practices. It is important to establish players' current behavioural knowledge about protective equipment before effective efforts to promote protective equipment can be developed.²⁴

Van Tiggelen D et al, 2008²⁵ proposed preventative measures would become more effective if an efficient and encompassing method of gaining individual's compliance across the required population was achieved. In addition, if a method of prevention could be introduced that does not rely on individuals' behaviour modification, then the effectiveness of the measure would remain unaffected by their compliance.

Another recent concept that may be possibly utilized in sports injury prevention, is the participatory approach. Although various behavioural change models exist, arguably the participatory approach works best.²⁶ In its simplest terms, the participatory approach is one in which everyone who has a stake in the intervention, has a voice, their perspective is considered, either in person or by representation. Staff of the organization (sports clubs) that will run it, members of the target population (team captains/ players), community officials (referees/ judges), interested citizens (supporters), and people from involved agencies (insurance, medical) and other institutions all should be invited to the table. Participation carries with it feelings of ownership, and builds a strong base for the intervention credibility in the community. If people are integral in the planning of a community intervention, then they will consider the intervention as theirs. They have a stake in it not only as its beneficiaries or staff or sponsors, but as its originators. They'll do what they can to ensure that their work succeeds.²⁶

Sporting bodies and clubs are usually supportive of intervention research, and will promote the adoption of safety behaviours. The recent UEFA study provided convincing evidence that injuries had a significant influence on performance in the league play and in European Cups in male professional football. The findings stress the importance of injury prevention in order to increase a team's chances of success.¹³

One of the more recent research efforts to achieve the above, has been intervention mapping (IM). This is a protocol for developing theory-and evidence-based interventions. IM describes the development process in six steps: (1) needs assessment, (2) specifying performance objectives and change objectives, (3) selecting theory-based intervention methods and practical applications, (4) designing and organizing the intervention, (5) specifying adoption and implementation plans, and (6) generating an evaluation plan. In IM, each performance objective is crossed with its determinants, resulting in the formulation of change objectives. These are specific goals of an intervention - to change the determinants of sub-behaviours. How IM can be intergrated in sports injury prevention, still remains an area for future research.^{27,28}

Different intervention strategies and methods are available for working with individuals and communities. For example, at the individual level, typical intervention strategies include a variety of behavioural, education, counselling, skill development, and training methods. Innovative new technologies such as computer-tailored messaging and behavioural prescriptions, web-based learning^{29,30} and motivational interviewing^{31,32} are promising approaches toward strengthening the impact of individual-level interventions. This concept has shifted the focus from intervention studies being conducted within the real-world context towards evaluating an intervention that is applicable, useable and adoptable by the real world context.^{31,32} More research is required to determine how technologies can be intergrated into the sports community in the prevention and treatment of injuries.

Outline of the study

Background

The game of American flag football (AFF) has been around for nearly as long as tackle football (since the mid-1800s), although Webster's Dictionary officially dates flag football to 1933. Not long afterwards, by the 1940s, it was all the rage on U.S. military bases as servicemen chose sides and played against each other. Since America could not send football-battered soldiers into combat, tackling a ball carrier to stop the player was replaced with the safer practice of grabbing a flag attached to his clothing. When the flag was taken, the player was stopped.³³ Recreational leagues began in the 1940s and 50s. By the 1970s, flag football had infiltrated college campuses and intramural teams formed, with students at each school playing against each other.³⁴ Currently, the sport has a strong amateur following worldwide, and is now played in Austria, Brazil, Canada, Denmark, France, Germany, Israel, Italy, Japan, Korea, Kuwait, Mexico, Norway, Panama, Sweden, Switzerland and the United States, with several national and international competitions each year. Many other “national organizations” have formed since the mid 90’s to take advantage of the estimated more than 20 million players participating in flag football programmes. The IFAF Flag Football World Championship has been held since 2002 and is the showpiece event for senior national teams competing in 5-on-5 flag football.

Previous Literature

The published literature regarding injuries in flag football is very limited, despite the sport's growing popularity in many countries. In a study on American army recruits, AFF was the third-leading producer of injuries in the sports and recreation category, behind basketball and softball. Overall flag football was eighth in both total injuries and total lost workdays among active duty military reports. However, it remains unclear whether this is due to the risk of injury or due to the high number of participants.³⁵ The incidence rate in contact flag football is relatively low (0.11 per 1000 athletic exposures (AEs)³⁵ compared with high school football injuries (4.08 per 1000 AEs)³⁷, high school soccer injuries (2.39 per 1000 AEs)³⁸, high school basketball injuries (1.94 per 1000 AEs)³⁹, first Division Spanish football injuries (5.65 injuries per 1000 AEs)⁴⁰, and professional football injuries (9.4 injuries per 1000 AEs).⁴¹

There are two published articles related to injuries in flag football and both are epidemiological studies.^{35,42} The first study³⁵ consisted of males only and was a retrospective, descriptive report consisting of data that was derived from safety reports obtained from the USAF (United States Air Force) Ground Safety Automated System. The injury statistics of the second study⁴² (involving only females) may not necessarily be representative of AFF, as female flag football is known to be less aggressive than the male version.⁴³ An additional difference between male and female leagues is that blocking is not permitted in the latter, which significantly reduces player-on-player contact and therefore, may have a significant impact on the epidemiology of the injuries. There have been no published studies that presented specific flag football mishap or injury prevention programmes.

Although contact flag football does not involve tackling and the injuries sustained may be considered "minor", large costs, including treatment and rehabilitation, may be associated with managing these apparently "minor" injuries. In a study that quantified the cost of sports injuries in a population of 15,038 high school varsity athletes from a mix of 12 different sports, most of these injuries resulted in less than 1 week's loss of sports participation. However, even these relatively "minor" injuries resulted in a substantial cost to society. These injuries resulted in approximately \$941 000 per year in medical costs (\$187 per athlete), \$4.2 million per year in human capital costs (\$838 per athlete), and \$13.7 million per year in comprehensive costs (\$2733 per athlete).⁴⁴ Seventy per cent of the injuries in the AFF epidemiological study³⁶ (Chapt.2.) were reported to be moderate to severe type-injuries (8-28 days off play), reflecting the high degree of physical contact in this allegedly "non-tackle", yet contact sport. This being the case, how much more would these moderate to severe type injuries place a large financial burden on society!

Main Aims of the Study

The principal aim of the study was to significantly reduce the **incidence** and **severity** of injuries in contact flag football. This included:

1. A prospective study evaluating the epidemiology of sport injuries in AFF (Chapter 2).
2. A prospective injury prevention pilot study (Chapter 3).
3. A 2-season prospective intervention study (Chapter 4) .
4. To ensure that the successful implementation methods would not only become a permanent aspect of the sport on a local and national level, but that an earnest attempt would be made to convince the International Federation of Flag Football (IFAF) to in fact change the rules at an international level as well.

The outline of the study and its continuation, will be presented using the TRIPP framework¹¹:

1. The TRIPP Stage 1 is that of injury surveillance

Chapter 2 describes the injury surveillance study that was undertaken over the 2007-2009 seasons, in the American Flag Football league in Israel (AFI).

2. The TRIPP Stage 2 corresponds to understanding the etiology of why injuries occur

In order to understand the etiology of the injuries, the indepth injury-surveillance questionnaires were analysed, the causes and mechanisms of the most common injuries extrapolated, and the data statistically analysed (Chapter 2).

3. The TRIPP Stage 3 involves the identification of potential solutions to the injury problem and development of appropriate preventive measures

The results of TRIPP Stage 2 led to potential solutions to the causes and mechanisms of the main injuries and appropriate intervention measures were developed for implementation in the one-season pilot study (Chapter 3.) and the 2-season intervention study (Chapter 4).

4. The TRIPP Stage 4 corresponds to intervention efficacy assessment

Efficacy measures how well preventative measures work in clinical or intervention trials⁴⁵ The efficacy of the intervention methods were assessed by both comparing the injury incidence rate and incidence proportion between the epidemiological study injury results (chapter 2) and those of the intervention study (chapter 4). Another aspect of assessing the efficacy of the intervention was to compare the compliance of the interventions used in the pilot study (chapter 3) vs. the compliance results in the 2-season intervention study (chapter 4).

5. The TRIPP Stage 5 is necessary to understand how the outcomes of the efficacy research can be translated into actions that can be actually implemented in the real-world context of on-field sports behaviours.

When the scientific efficacy of a preventative measure has been proven, it then may be considered for implementation by the stakeholders (e.g. sports federations, team managers)²⁵ In order to test how the outcomes of the efficacy research could be translated into actions that may actually implemented in the real-world context, the principal study author (YK) met with the AFI management and convinced them to conduct a follow-up study over the next 2 seasons (2014-5), where the study interventions, the new rule changes and penalties would be in force. The interventions would be implemented not within the confines of a efficacy study, but rather under the independent control of the stakeholders themselves (participatory approach²⁶). This stage was not part of the author's current study and therefore will not be discussed further.

6. The TRIPP Stage 6 involves both implementing the intervention in a real-world context and evaluating its effectiveness.

As opposed to efficacy, effectiveness relates to how well a treatment works in the practice of medicine (ie. the real world).⁴⁵ In order to implement the intervention in the real-world context, the AFI management agreed to conduct a follow-up study over the next 2 seasons (described in Tripp Stage 5). In order to evaluate the effectiveness of this management-controlled prevention programme, the player compliance, injury incidence rates and incidence proportion will be then be compared to the author's previous 2-season cohort study, to evaluate whether the interventions, rule and penalty changes could be maintained, not only within the context of a strictly-controlled intervention study (i.e efficacy), but rather under the control of the league itself (effectiveness). It will further evaluate whether these interventions, rules and penalties will remain a permanent feature of the game of flag football, thus making the sport safer for all future generations of players. As with Tripp Stage 5, this stage however was not part of the author's current study and therefore will not be discussed further.

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CHAPTER 2

The Epidemiology of Injuries in Contact Flag Football

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The Epidemiology of Injuries in Contact Flag Football

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ABSTRACT

Objective: To characterize the epidemiology of injuries in post-high school male and female athletes in the rapidly growing international sport of contact flag football.

Design: Prospective injury-observational study.

Setting: Kraft Stadium, Jerusalem, Israel.

Participants: A total of 1492 players, consisting of males (n=1252, mean age, 20.49 ± 5.11) and females (n=240, mean age, 21.32 ± 8.95 yrs), participated in 1028 games over a 2-season period (2007-2009).

Main Outcome Measures: All time-loss injuries sustained in game sessions were recorded by the off-the-field medical personnel and followed up by a more detailed phone injury surveillance questionnaire.

Results: One hundred and sixty-one injuries were reported, comprising 1,533,776 athlete-exposures. The incidence rate was 0.11 (95% CI: 0.09, 0.12) per 1000 athletic exposures and incidence proportion was 10.66% (95% CI: 9.10, 12.22). Seventy-six percent of the injuries were extrinsic in nature. Thirty percent of the injuries were to the fingers, thumb and wrist, 17% to the knee, 17% to the head/face, 13% to the ankle, 11% to the shoulder.

Conclusions: Contact flag football results in a significant amount of moderate to severe injuries. This data may be used in the development of a formal AFF injury database, as well as in the development and implementation of a high-quality, randomized, prospective injury prevention study. This study should include the enforcement of the no-pocket rule, appropriate head gear, self-fitting mouth guards, the use of ankle braces, and changing the blocking rules of the game.

INTRODUCTION

American flag football (AFF) is a version of American football that has become very popular worldwide, and is now played in the United States, Canada, Mexico, several leading European countries, Korea, Dubai and Israel. The sport has a strong amateur following and hosts several national and international competitions. The basic rules of the game are similar to those of the mainstream football game (often called "tackle football" for contrast), but instead of tackling players to the ground, the defensive team must remove a flag or flag belt from the ball carrier ("deflagging") to end a down.¹

Primarily because there is no dominant sanctioning organization for the sport, the game has evolved into many variations and may also be divided into "contact" or "non-contact", depending on whether or not blocking is allowed.² The AFF league in Israel (AFI) was established 21 years ago in Jerusalem and has rapidly expanded to a national league consisting of more than 90 teams (with over 1000 players), including a men's, women's, high school and mixed league. The annual season runs from October to February. Most teams play one game per week and all games are equal in length (60 minutes). The teams have a few practice sessions prior to the commencement of the playing season and usually do not practise during the season itself.

The aim of this study was two-fold: I. To characterize the epidemiology of injuries in post-high school male and female athletes II. To recommend ideas for a future, prospective injury prevention study.

METHODS

Study participants included caucasian post-high school male and female American and Canadian pre-college students, who had registered to play in the AFI league over the 2007-2009 seasons. Their demographic data is displayed in Table 1. All were studying in religious study academies in Israel, were all of similar age, socio-economic backgrounds (similar levels of education and little ethnic diversity), and played the same number of games during the flag football season.

The attending paramedics, who had completed a full paramedics course through the Magen David Adom organization in Israel, conducted a quick off-the-field assessment following each injury. The appropriate first-aid care was then administered. All time-loss injuries were recorded on the standard league injury form by the on-duty paramedics. Injured players were either referred to their local physician or sent to the emergency unit of the local hospital. As there were no paramedics at the practice sessions, no exposure was collected.

For the purposes of this study, only time-loss injuries were counted as injuries. A time-loss injury was defined as an injury that resulted in a player being unable to return to future training or current game. The term “future” referred to any time after the onset of injury, including the day of injury.³ The forms were collected manually by the principal author (YK). A telephonic, in depth injury-surveillance questionnaire was then conducted by the same author (YK) and was administered within a day or two following the injury (Fig 1.). The injury assessment questionnaire was based on the internationally accepted consensus injury surveillance questionnaire recommendations of Fuller³ and was designed more specifically for AFF. Physicians were requested to provide a specific written diagnosis or to use a sport specific injury coding system, such as the Orchard system.⁴ This was done in order to reduce the possible risk of injury misclassification. It was not possible to collect any pre-season baseline measures, since the player registration process was done via the AFI website, to

which the authors had no access. During the signing of the study consent forms, the authors did however have the cohort fill in a short questionnaire related to previous ankle sprains.

League	Males	Females	Group Total
No. of games played	846 (84%)	182 (16%)	1028
No. of teams	116 (81%)	28 (19%)	144
No. players	1252 (84%)	240 (16%)	1492
Age Average (yrs)	20.49	22.44	20.71
SD	4.89	7.58	5.27
Height Average (m)	1.76	1.65	1.75
SD	0.96	0.89	0.10
Weight Average (kg)	80.67	62.59	78.87
SD	16.89	9.21	17.15

Table.1 Baseline demographic data

League	Male	Females	Group Total
No. of injured players	141 (89%)	19 (11%)	159
No. of injuries	145 (90%)	19 (10%)	164
Athlete Exposures	1,059,192	43,680	1, 533,776
Incidence Rate per 1000 athlete exposures	0.14 (95% CI: 0.12, 0.16)	0.39 (95% CI:0.20,0.57)	0.11 (95% CI: 0.09, 0.12)
Incidence Proportion	11.66 (95% CI:9.5, 13)	7.5% (95% CI:4.5,11.3)	10.66% (95% CI: 9.10, 12.22)

Table.2 injury result data

Injury Date: _____ Player Code: _____

1. Mechanism of Injury:

<input type="checkbox"/> knocked into another player	<input type="checkbox"/> contact with ground	<input type="checkbox"/> hit by object	<input type="checkbox"/> intrinsic
<input type="checkbox"/> hand/finger caught	<input type="checkbox"/> knocked by another player		

2. Cause of Injury: Overuse Trauma

3. Type of Injury:

<input type="checkbox"/> concussion	<input type="checkbox"/> Meniscus/ cartilage	<input type="checkbox"/> haematoma/ contusion	<input type="checkbox"/> fracture
<input type="checkbox"/> dislocation	<input type="checkbox"/> tendon injury/rupture	<input type="checkbox"/> nerve injury	<input type="checkbox"/> ligament
<input type="checkbox"/> abrasion/ laceration	<input type="checkbox"/> dental/ tongue injury	<input type="checkbox"/> muscle strain/rupture	<input type="checkbox"/> bursitis

4. Injured body part:

<input type="checkbox"/> head/ face/lips/tongue	<input type="checkbox"/> shoulder/ clavicle	<input type="checkbox"/> hip / groin	<input type="checkbox"/> neck/cervical spine	<input type="checkbox"/> upper arm
<input type="checkbox"/> thigh	<input type="checkbox"/> sternum/rib	<input type="checkbox"/> upper back	<input type="checkbox"/> elbow	<input type="checkbox"/> knee
<input type="checkbox"/> abdomen	<input type="checkbox"/> LB/ sacrum/pelvis	<input type="checkbox"/> wrist	<input type="checkbox"/> ankle	<input type="checkbox"/> fingers
<input type="checkbox"/> thumb	<input type="checkbox"/> foot/heel/toe	<input type="checkbox"/> lower leg/ Achilles	<input type="checkbox"/> lower arm	
Final diagnosis:				

5. Affected side: L R N/A **6. Dominant side:** L R

7. Recurrence: no

<input type="checkbox"/> Re-injury	<input type="checkbox"/> Recurrent (<2 months)	Late recurrence (2-12 months)
Exacerbation of current injury	<input type="checkbox"/> Recurrent (<2 months)	<input type="checkbox"/> Late recurrence (2-12 months)
		<input type="checkbox"/> Delayed recurrence (> 12 months)

8. Severity: (Days)

<input type="checkbox"/> Slight (0)	<input type="checkbox"/> Minimal (1-3)	<input type="checkbox"/> Mild (4-7)	<input type="checkbox"/> Moderate (8-28)	<input type="checkbox"/> Severe (>28)	<input type="checkbox"/> Career ending
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10. Field position: wide receiver tight-end quarter back center defensive line safety corner-back

11. Game: Game practice **12. League Type:** Mens Womens

13. Injury period: First Half (0-25) Second Half (25-50)

14. By Game rules: No Yes

15. Penalty? No Yes

16. Was player suspended No Yes

17. Field conditions: Dry Wet

18. Match sessions per wk: _____ **19. Practice sessions per wk:** _____

20. Football hours per wk: _____ **21. Years playing football:** _____

22. Previous Injuries

<input type="checkbox"/> concussion	<input type="checkbox"/> Meniscus/ cartilage	<input type="checkbox"/> haematoma/ contusion	<input type="checkbox"/> fracture
<input type="checkbox"/> dislocation	<input type="checkbox"/> tendon injury/ rupture	<input type="checkbox"/> nerve injury	<input type="checkbox"/> ligament
<input type="checkbox"/> abrasion/ laceration	<input type="checkbox"/> dental injury/ tongue	<input type="checkbox"/> muscle strain/rupture	<input type="checkbox"/> bursitis

23. Previous Injured body part

<input type="checkbox"/> head/ face	<input type="checkbox"/> shoulder/ clavicle (L/R)	<input type="checkbox"/> hip / groin (L/R)	<input type="checkbox"/> neck/cervical spine	<input type="checkbox"/> upper arm
<input type="checkbox"/> thigh (L/R)	<input type="checkbox"/> sternum/rib	<input type="checkbox"/> upper back	<input type="checkbox"/> elbow (L/R)	<input type="checkbox"/> knee (L/R)
<input type="checkbox"/> abdomen	<input type="checkbox"/> LB/ sacrum/pelvis	<input type="checkbox"/> wrist (L/R)	<input type="checkbox"/> ankle (L/R)	<input type="checkbox"/> fingers (L/R)
<input type="checkbox"/> thumb (L/R)	<input type="checkbox"/> foot/heel/toe (L/R)	<input type="checkbox"/> lower leg (L/R)	<input type="checkbox"/> lower arm (L/R)	
Final diagnosis				

24. Protective equipment: yes no What type? _____

Fig 1. Injury-Surveillance Questionnaire

The ethics committee of the Meir Hospital, Kfar Saba, Israel gave ethics approval for the study and all players were requested to sign a consent form prior to participation. During the 2007-2009 playing seasons, data was collected, statistically analysed, results discussed and appropriate conclusions were drawn.

STATISTICAL ANALYSIS

In order to compare the differences between the injured and non-injured, as well as the male and female players, the t-test for equality of variances was employed. For the purposes of cross tabulation, the Pearson Chi-Square test was used to determine whether there was a statistically significant correlation between the variables tested (Figs.3-5). Statistical analysis was undertaken via the use of SPSS® predictive analytics software package (version 18.0). The p-value of statistical significance was 5% or less.

RESULTS

A total of 1412 players (94%) agreed to participate in the study. Nine athletes refused to participate. The remaining 71 players, although registered to play, were unable to be contacted either due to the fact that their contact details were incorrect, or that they had changed their minds and had decided not to play in the league. The cohorts demographic, as well as injury result data is displayed in Tables 1 and 2 above.

Males and females exhibited a statistically significant difference with respect to weight and height ($p < 0.001$). There was no statistically significant difference between the injured players and a random sample of uninjured players with respect to age, height, weight, level of play, gender, number of games played, and previous ankle injury ($p < 0.05$). The injury risk for females was nearly 3-fold that of the males (0.14 vs 0.39). There were a total of 159 players injured, of which, 8 were lost to follow-up.

Eighty-eight percent of the injuries occurred in 5 anatomical regions (Fig.2). The remaining 12% ("other" in the body part list) included the ribs, neck, lower back, lower arm, pelvis, hip, thigh, foot and groin area. Eighty-seven percent of the injuries were extrinsic in nature (environmental),⁷ whereas 13% were intrinsic (personal)⁷. For the purposes of this study, an intrinsic injury was defined as any injury that excluded contact with another player, object or the ground. Of the extrinsic injuries, 11% were due to fingers being caught in the belt/pocket or flag of the opposing player's pants. Fifty percent were due to contact with another player, 18%, contact with the ground and 8% contact with an object (Fig.3). The term "other" in the injury type list, referred to other pathologies, including muscle strain/rupture, tendonopathy, bursitis and meniscal tear. There was a highly significant correlation between injury type vs. injury mechanism (Fig.3) (p value < 0.001). There was a highly significant correlation observed between body part vs. injury mechanism (Fig. 4) ($p < 0.001$).

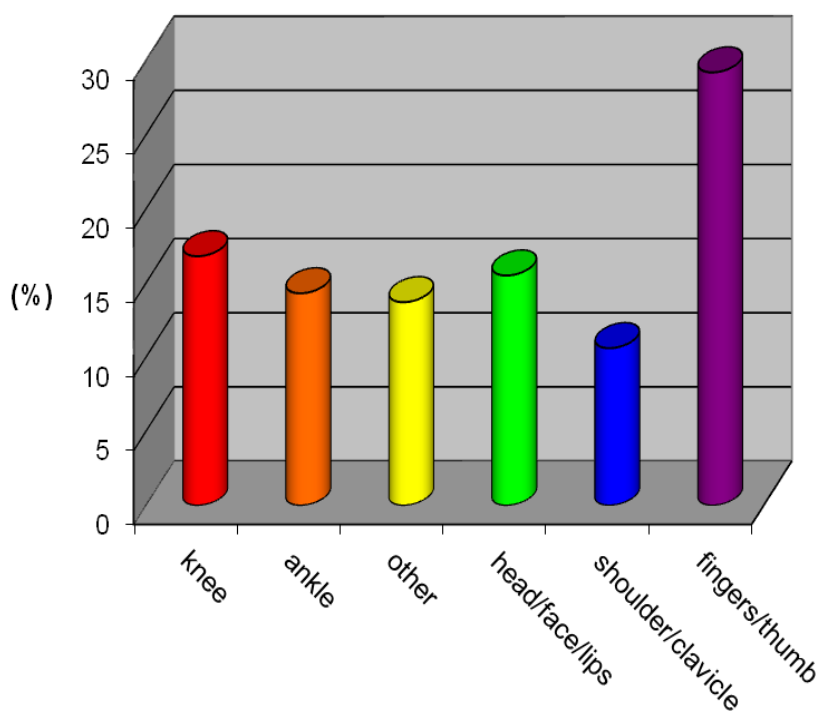


Figure 2. Anatomical distribution of injuries

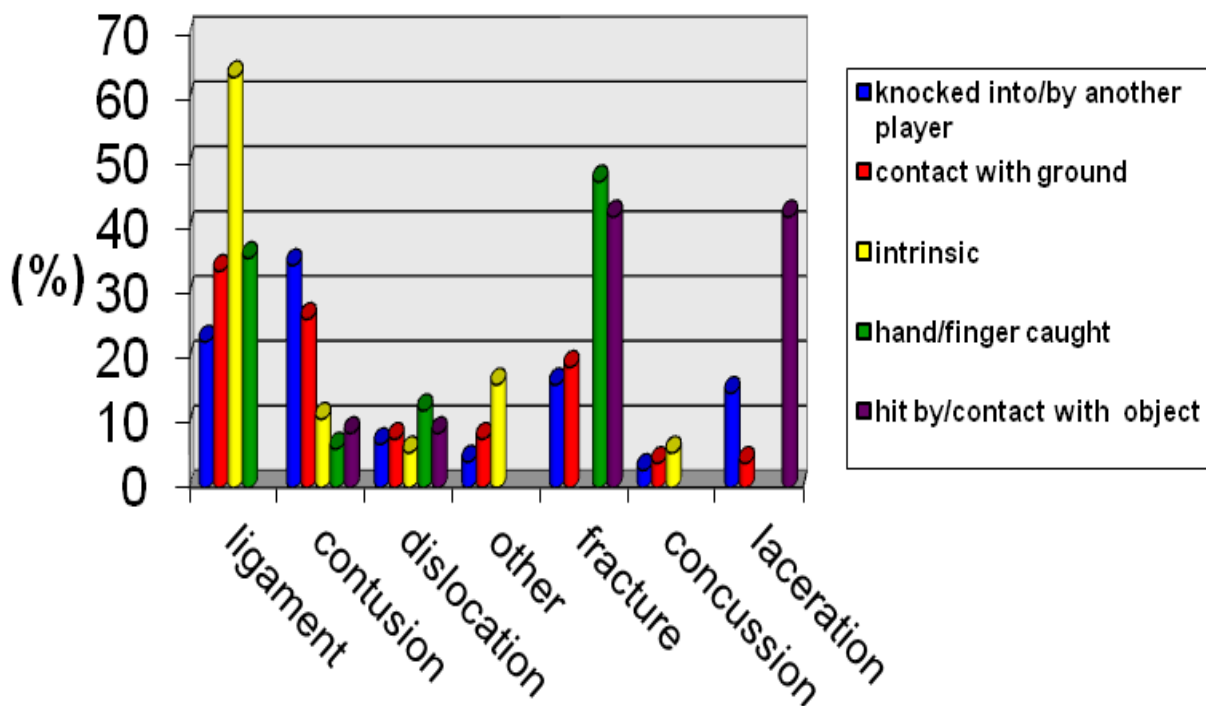


Figure 3. Injury Type vs. Injury mechanism

The majority of shoulder injuries were caused by the player colliding into or being bumped by another player (Fig.4). More than half of the pathologies were dislocations (Fig.5). One-third of the knee injuries involved the knee ligaments, of which, 83% were extrinsic in nature, and 50% were contusions and hematomas (Fig.5). There was a highly significant correlation between body part vs. injury type (Fig.5) (p value < 0.001).

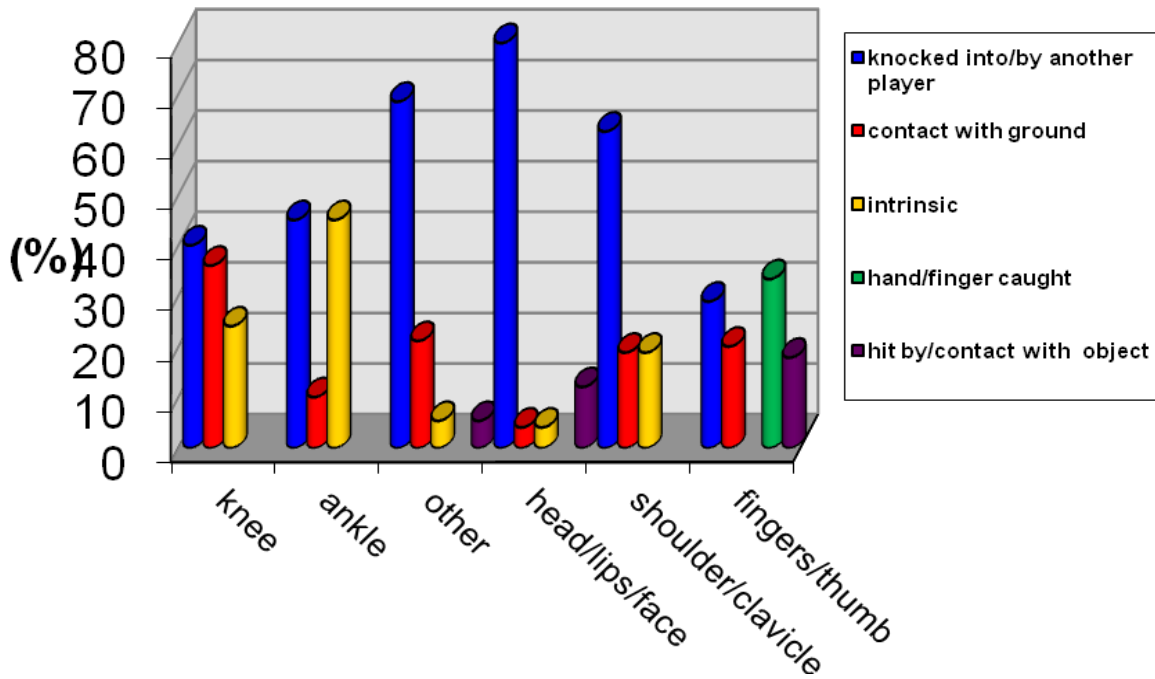


Figure 4. Body part vs. Injury mechanism

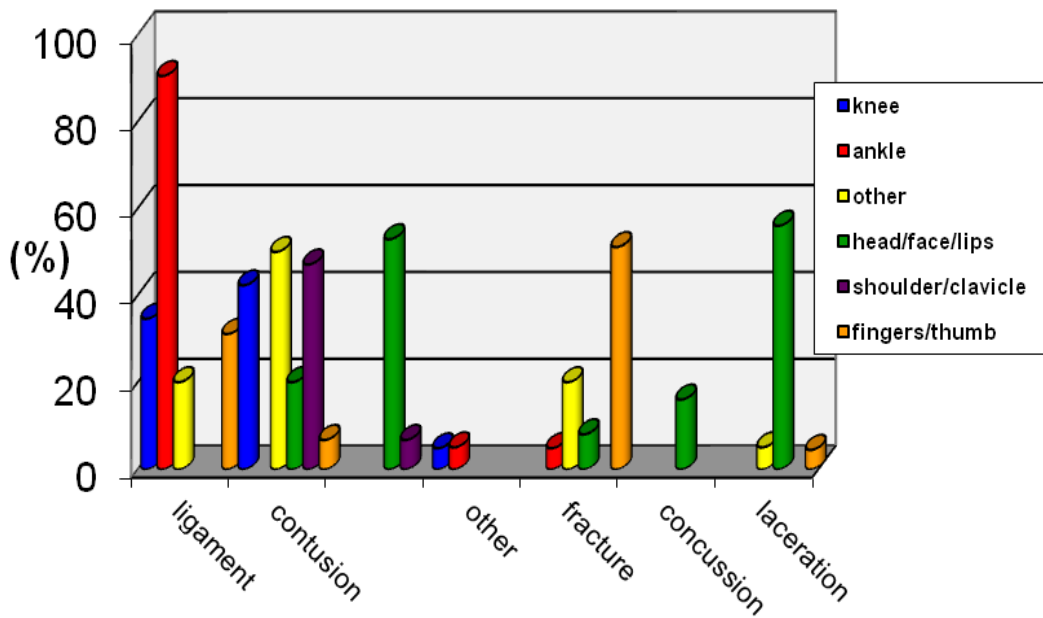


Figure 5. Body part vs. Injury Type

Player-position-injuries were distributed as follows: Thirty-one percent involved the defensive linemen, 24% the receiver, 15% the quarterback, 21% the offensive line (tight end and centre positions), 7% the cornerback and 2% the safety position. There was no significant correlation between injured body part vs. field position, nor between injury type vs. field position. A low correlation was observed between injury mechanism vs. field position ($p=0.05$). Sixty-six percent of the injuries reported were either described as moderate (8-28 days before returning to playing) or severe (> 28 days before returning to playing).³

DISCUSSION

This is the first prospective study evaluating the epidemiology of both male and female sport injuries in AFF. The published literature regarding flag football was found to be very limited, despite the sport's growing popularity in so many countries. There have been no published studies that presented specific flag football mishap or injury prevention programmes. There were however, two published articles related to injuries in flag football and both were epidemiological studies.^{5,6}

The first was a prospective observational study of female flag football injuries, in which there were 114 reported injuries.⁵ Thirty-nine percent occurred in three anatomical regions: Fifteen percent the fingers/wrist, 16% the knee and 8% the ankle. Collisions with other players and objects resulted in 64% of these injuries. Offensive ball handlers (running backs and receivers) had the greatest probability of being injured. The authors did not make any recommendations for the prevention of injuries. Although some of the injury statistics were similar to the author's observational study, the study results may not necessarily be representative of AFF, as female flag football is known to be

less aggressive than the male version.⁸ An additional difference between male and female leagues is that blocking is not permitted in the latter, which significantly reduces player-player contact and therefore, may have a significant impact on the epidemiology of the injuries. This was not apparent in the current study, where the injury risk for females was nearly 3-fold that of the males. When analyzing specific anatomical areas involved in injuries, 26% of the female injuries were associated with the knee area, as compared to 7.6% in the men. Women's participation in intercollegiate athletics has increased dramatically in recent years. Greater participation has increased awareness of health and medical issues specific to the female athlete. Some reports have noted a higher susceptibility to knee injury, specifically injuries to the anterior cruciate ligament, in female athletes as compared with their male counterparts.⁹

The second and most recent article was a retrospective, descriptive report consisting of data that was derived from safety reports obtained from the USAF (United States Air Force) Ground Safety Automated System. The authors suggested strategies to prevent possible injuries for some of the eight mechanisms of injury identified in their manuscript. The criterion used to define an injury was based on one lost workday, as opposed to the more widely accepted criterion, which was the inability to continue to play for at least one game.³ Nonetheless, some of their data (anatomical regions injured and percentage of injuries related to contact with another player and/or the ground), were very similar to the results of the author's observational cohort.

The incidence rate in the present observational cohort was significantly lower than in other high-contact sports. In high school basketball for example, the injury rate has been reported to be 1.94 per 1000 athletic exposures (AEs),¹⁰ whereas it was found to be 2.39 per 1000 AEs in high school

soccer.¹¹ This may be explained by the fact that AFF is a non-tackle sport, with less contact between players than in other sports. As the game of AFF involves "deflagging" and blocking is permitted with the hands, the anatomical distribution of injuries is very different from other upper limb, ball-playing sports. In the present study, the hand and wrist comprised 30% of the injuries while 13% were ankle injuries. In basketball for example, arm/hand injuries comprised only 9% of the injuries, while ankle/foot injuries comprised 40% of reported injuries.¹⁰

Despite the fact that most of the injuries (81%) resulted from either direct contact with the ground, another player or with an object, very few players (19%) used any form of protective equipment. This was especially apparent regarding injuries to the wrist and hand. Although more than one-third of all the injuries involved the wrist and hand, only 2 players (0.07%) had taken measures related to injury prevention in this anatomical location, and both only post-injury.

Nearly 40% of all hand/finger injuries (which made up 30% of all total injuries) were a direct result of fingers being caught in the opposing player's pants pockets. This information was extracted directly from the detailed injury questionnaire. Most players in this study wore pants with pockets, even though this violated International Flag Football Rules². The authors therefore recommend, as do both previously cited studies in this article^{5,6}, that coaches, team captains, referees and management of AFF take a more active and aggressive role in enforcing the no-pocket rule.

Seventy-four percent of the head/face injuries were contusion-type injuries. Recent investigations have suggested that a protective, but not preventive, effect may be afforded by mouth guard use in rugby players and customized mandibular orthotic use in football players.¹² Mouth guards in

particular have been shown to prevent oral and tongue injuries and may reduce the severity of concussions.^{13,14} Very few players in the study cohort used them, despite the fact that their usage is recommended according to International Flag Football Rules.² It is imperative that coaches, team captains, referees and management of AFF take a greater role in ensuring that all players use an intra-oral mouthpiece of a visible colour.² It has been suggested that the use of headgear in soccer players may reduce the incidence of concussions.¹⁴ Following discussion with coaches and players in the AFI, it became evident that the use of headgear in flag football would more than likely be unsuccessful, despite its potential for reducing head injuries. The prevalent viewpoint of the stakeholders is that flag football is a non-tackle sport and therefore players choose this sport in order to avoid wearing protective headgear.

There is some debate in the literature as to whether knee braces play a significant role in preventing knee injuries. Research is limited on the use of knee braces (prophylactic and functional) to potentially prevent knee ligament injury in the non-injured population. One possible explanation for the limited research could be that the use of these devices has raised concerns of decreased or impaired athletic performance.¹⁵ They have not proven to be effective in reducing the number and severity of knee injuries.^{16,17}

Neuromuscular preventative programmes have been shown to reduce the incidence of non-contact knee injuries.^{18,19,20,21} In this study, 76% of the knee injuries were as a result of direct contact with the ground or with another player (Fig.4.) Neuromuscular preventative programmes have yet to be investigated in reducing injury risk in contact-type sports.

Thirteen percent of all the injuries in the study cohort were to the ankle. Ninety-five percent of them were ligamentous in nature and 5% of them were fractures (Fig.5). In this study cohort, a previous sprain did not prove to be a confounder/risk factor. This result does not comply with previous findings in other sports.²² However, players were asked about previous sprains not only limited to AFF, and therefore these sprains could have resulted from other activities, not necessarily related to flag football. Ankle braces have proven to be successful in significantly reducing ankle injuries in sport, primarily in those players with recurrent sprains.^{23,24,25} Very few players in the study cohort used them. All AFF players, and especially those with recurrent sprains, may consider the use of ankle braces in order to reduce the incidence of ankle sprains.

As reported previously, most of the shoulder injuries were a result of player-player contact. A recent study reported very similar percentages to the present investigation²⁶. The authors concluded that although dislocation/separation injuries represent a relatively small proportion of all injuries sustained by high school student-athletes, the severity of these injuries indicates a need for enhanced injury prevention efforts. Other than changing game rules to reduce the incidence of player-player contact, previous attempts to reduce the impact of shoulder injuries by the use of pads have proven unsuccessful. The pads appear to "bottom out" under higher-impact loads and therefore offer little protection when the athlete may need it most²⁷.

Four (2.6%) of the observed injuries were concussions. Traditionally, on-field signs and symptoms included confusion, loss of consciousness, post traumatic amnesia, retrograde amnesia, imbalance, dizziness, visual problems, personality changes, fatigue, sensitivity to light/noise, numbness, and

vomiting.²⁸ In this study, any of these symptoms, that prevented the player from returning to the same game, were defined as a concussion.

The highest prevalence of injuries involved players at the positions of the defensive line (26%) and wide receiver (30%). This may be due to the fact that these positions involve a higher level of physical contact than others. The objective of the defensive lineman position is to reach the quarterback (QB) as quickly as possible, to prevent or to obstruct a pass. The wide receiver's objective is to get past the defensive cornerback, in order to be open to receive a pass. The cornerback is allowed to push the wide receiver only within the first 4.5 metres past the line of scrimmage. This puts the wide receiver on the receiving end of physical contact.

Although AFF is a non-tackle, rather contact, sport, certain types of blocking are allowed. While blocking to the back, face or holding is prohibited, blocking to the body and to the hands is permissible.² The high number of moderate to severe type injuries, as well as their high injury incidence rate, reflects the high degree of physical contact in this allegedly "non-tackle", yet contact sport.

Limitations of the study included the possibility of underreporting of injuries. This may have occurred due to players being injured towards the end of a game and therefore deciding not to report the injury. Additionally, many failed to report their injuries for personal reasons, and some refused to comply with the questionnaire. Over the weeks prior to the playing season, the 144 teams practised in many different locations as well as set their own time schedules. It was therefore decided by the AFI league management not to have paramedics attend the practice sessions. It has been well established

that there are fewer injuries during practice vs. match sessions.^{29,30} The authors felt that although this may have lead to underreporting of injuries, it would not have significantly influenced the injury incidence rates.

The study included a specific-age population (pre-college male and female students) and therefore the possibility exists that the injury rate may be higher in a younger or in an older athletic population. Although a telephonic, in-depth questionnaire was conducted by the same author within a day or two following the injury, there were cases where the player's condition necessitated a follow-up medical investigation, and therefore a final diagnosis was only made 7-14 days post-injury. Although the authors felt that this time period was short enough that players would not suffer from recall bias, the possibility still existed.

CONCLUSION

Contact flag football results in a significant amount of moderate to severe injuries. The high incidence of injuries to the hand, head and face, differentiate injuries in contact flag football from other contact sports. Areas of future study may include the development of a formal AFF injury database, as well as the implementation of a high-quality, randomized injury prevention programme. This programme should include the enforcement of the no-pocket rule, wearing appropriate head gear, using self-fitting mouth guards, comfortable ankle braces, and investigate changing the blocking rules of the game.

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CHAPTER 3

THE PREVENTION OF INJURIES IN CONTACT FLAG FOOTBALL

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**"Everything should be made as simple as possible,
but not simpler"**

- Albert Einstein

ABSTRACT

Purpose: American flag football (AFF) is a non-tackle, contact sport with many moderate-severe contact-type injuries reported. A previous prospective injury surveillance study by the authors revealed a high incidence of injuries to the fingers, face, knee, shoulder and ankle. The objectives of the study were to conduct a pilot-prospective injury prevention study in an attempt to significantly reduce the incidence and the severity of injuries as compared to a historical cohort. Additionally, to provide recommendations for a future prospective injury prevention study.

Methods: A prospective injury prevention study was conducted involving 724 amateur male (mean age: 20.0 ± 3.1 yrs) and 114 female (mean age: 21.2 ± 7.2 yrs) players. Four prevention measures were implemented: The no-pocket rule, self-fitting mouth guards, ankle braces (for those players with recurrent ankle sprains) and an injury treatment information brochure. An injury surveillance questionnaire was administered to record all time-loss injuries sustained in game sessions.

Results: There was a statistically significant reduction in the number of injured players, the number of finger/hand injuries, the incidence rate (IR) and the incidence proportion (IP) between the two cohorts ($p < 0.05$).

Conclusions: This one-season pilot prevention study has provided preliminary evidence that finger/hand injuries can be significantly reduced in flag football. Prevention strategies for a longer, prospective, randomised-controlled injury prevention study should include the strict enforcement of the no-pocket rule, appropriate head gear, the use of comfortable-fitting ankle braces and mouth guards and changing the blocking rules of the game.

Level of evidence: II

Key words: Contact flag football, Sports injuries, Prevention, Intervention study

INTRODUCTION

American flag football (AFF) is played in a similar manner to American football. However there are several differences, AFF is played on a smaller field, the number of players per team ranges between five and nine players, and players are not allowed to wear pads of any kind. In AFF, instead of tackling the ball carrier, flags are clipped to a belt that is worn around the ball carrier's waist, and the removal of a flag is equivalent to a tackle. AFF provides participants with the opportunity to develop many of the same skills, tactics and strategies as American Football, but without significant physical contact [30]. The AFF winter league in Israel (AFI) was established 25 years ago in Jerusalem and has rapidly expanded to a national league that consists of more than 90 teams (with over 1000 players), including a men's, women's, high school and mixed league.

In a study on American army recruits, AFF was the third-leading producer of injuries in the sports and recreation category, behind basketball and softball [3], thus despite its lowered physical contact and injury susceptibility compared to tackle football, it has a relatively high injury incidence. These authors, as have others, proposed that further research or evaluation of prevention strategies is needed [11, 14, 29].

Three previously published epidemiological studies reported on injuries in flag football [3, 5, 18]. All three reported a high percentage of injuries to the fingers/wrist (ranging between 16-34%), the knee (ranging between 11-16%), the ankle (ranging between 8-12%) the face and head (18%) and the shoulder (9%). Direct trauma was responsible for the vast majority of injuries (ranging between 64-75%). In the latest of these three studies, conducted by the authors of the present manuscript, forty percent of the hand/finger injuries were reported as a direct result of fingers being caught in the opposing player's pants [18]. Almost all players in this study wore pants with side pockets and

refrained from playing with mouth guards, despite evidence that they have been shown to prevent oral and tongue injuries and that they might reduce the severity of concussions [4, 6, 21]. Both of the above are in violation of the International Flag Football Rules [12]. Although ankle braces have proven to be successful in reducing ankle injuries in sports, primarily in those players with recurrent sprains [9, 16, 23], very few players in the study cohort used them. There are no published studies that presented specific flag football mishap or injury prevention programmes.

The aim of this study was two-fold:

- I. To conduct a one-season pilot-prospective injury prevention study (experimental cohort) in an attempt to significantly reduce the incidence and the severity of sports-related injuries in AFI, as compared to a historical cohort.
- II. To provide recommendations for a future 2-season prospective injury prevention study.

MATERIALS AND METHODS

Pre-college American and Canadian males and females, who had registered to play in the AFI amateur league over the 2010/2011 season, participated in the study. Most study participants were of similar age, socio-economic background (had similar levels of education and were from the same ethnic communities) and played a similar number of games during the league season. All players were required to register via the AFI website. The players received information via electronic media that pertained to the study aims and protocol. A meeting was held prior to the season with all the paramedics and the AFI management, where the study's rationale and aims were explained, as well as the definitions of what constitutes a time-loss injury and an outline of the on-the-field questionnaire. A time-loss injury was defined as an injury that resulted in a player being unable to return to the current or future game [7].

Following agreement with the management of the AFI, four intervention measures were implemented:

- I. The no-pocket rule.** Players were not permitted to play with pants which had open side pockets. The pockets were either glued (fabric glue) or taped by the principle author (YK) or by the players themselves.
- II. Self-fitting mouth guards (Everlast™ Double Mouth Guard).** Prior to the first game of the season, the principle author (YK) distributed mouth guards to each player with instructions related to the moulding and fitting process.
- III. Ankle braces (Universal Ankle Stirrup DJO™).** They were distributed to those players who reported a history of at least two previous sprains on the ipsilateral ankle, with accompanying instability and within the previous five year period.
- IV. An injury treatment information brochure.** The purpose of this brochure was to reduce the severity of the injuries [7]. It provided information on how to effectively treat an injury in the acute phase (P.R.I.C.E.M method [2,13,15]) as well as information pertaining to medical facilities in the event of an injury.

As the AFI is an amateur league, there are no official league practice sessions held during the season. All teams play one game per week. Injured players were either referred to their local physician or sent to the emergency unit of a local clinic or hospital.

The attending paramedics recorded only time-loss injuries throughout the playing season. These were collected manually by the principal author (YK) following the conclusion of all games that were scheduled for that day. A telephonic, in depth injury-surveillance questionnaire was administered within a day or two following the injury. The questionnaire was based on the internationally accepted

consensus injury-surveillance questionnaire recommendations of Fuller et al. [7] and was further adapted for AFF. Physicians were requested to provide a specific written diagnosis or to use a sport specific injury coding system, such as the Orchard system [24]. This was done in order to reduce the possible risk of misclassification of injury.

In order to evaluate the compliance rate of the intervention methods used, all players who had received ankle braces were contacted telephonically upon the termination of the season. A brief questionnaire (Fig.1) was completed including questions pertaining to the use of mouth guards as well as compliance with the no-pocket rule.

AFI COMPLIANCE QUESTIONNAIRE

1. NAME: _____
(first last)
2. AGE: _____ HEIGHT : _____ (Metres / Feet)
3. WEIGHT : _____ (Kilos/ Pounds) DOMINANT LEG: R L
4. NO. GAMES PLAYED IN SEASON: _____
5. FIELD POSITION (Select the **one** position you played the most)
 - a. Wide Receiver
 - b. Tight-end
 - c. Quarterback
 - d. Center
 - e. Defensive Line
 - f. Safety
 - g. Corner-Back
6. RECEIVED ANKLE GUARD: Y N
7. HOW MANY GAMES DID YOU WEAR THE ANKLE GUARD: _____
8. REASON NOT USED (please select the most applicable reason)
 - a. Uncomfortable
 - b. Hard to run with it
 - c. Lost it
 - d. Other _____
 - e. Forgot it
 - f. Ankle wasn't hurting
 - g. Didn't feel "necessary"
9. RECEIVED MOUTH GUARD: Y N
10. HOW MANY GAMES DID YOU WEAR THE MOUTH GUARD: _____
11. REASON NOT USED (please select the most applicable reason)
 - a. Uncomfortable
 - b. Hard to run with it
 - c. Lost it
 - d. Other _____
 - e. Forgot it
 - f. Ankle wasn't hurting
 - g. Didn't feel "necessary"
12. DID YOU PLAY WITH OPEN POCKETS? Y N
13. GAMES PLAYED WITH OPEN POCKETS _____
14. DO YOU USE OTHER PROTECTIVE EQUIPMENT? Y N
TYPE: _____ NO. GAMES WORN _____
TYPE: _____ NO. GAMES WORN _____

Figure 1. Compliance Questionnaire

The ethics committee of the Meir Hospital, Kfar Saba, Israel provided ethics approval for the study and all players were required to sign a consent form prior to participation.

STATISTICAL ANALYSIS

In order to compare the physical characteristics and severity of injury between the players in the historical cohort and the intervention cohort, the paired 2-tailed t-test for equality of means was used. For the purposes of cross-tabulation of the study variables, the Pearson chi-square test was employed. The Pearson's chi-square test with Yates correction was used to determine whether there was a significant correlation between the two cohorts relating to body parts injured, the number of injuries reported and number of injured players. Statistical analysis was undertaken via the use of SPSS® predictive analytics software package (version 18.0), as well as the WinPepi package of statistical programmes (PEPI-for-Windows) (version 11.18). With the assistance of the "Power and Precision" statistical power analysis software package, the calculation of a sample size for the planned study was computed. The p-value of statistical significance was 5% or less.

RESULTS

There was no significant difference between the two cohorts with respect to their demographic data (p<0.05)

Cohort	Avg No. Games	Avg No. Teams	Avg No. Players	Avg Age	Avg Height (m)	Avg Weight (kg)
Historical	514	72	706	20.7	1.8	78.6
SD				5.3	0.1	17.1
Males	423(82%)	58(81%)	593(84%)	20.5	1.8	80.7
SD				4.9	1	16.9
Females	91(18%)	14(19%)	113(16%)	22.4	1.7	62.6
SD				7.6	0.9	9.2
Pilot	464	64	724	20.2	1.8	74.3
SD				3.7	9.2	16.5
Males	372	51	610	20.0	1.8	76.6
SD				3.1	8.6	15.8
Females	92	13	114	21.2	1.7	60.9
SD				7.2	8.3	15.3

Table 1. Baseline Demographic Data

There was a reduction in the number of injuries in all body parts, although it only reached statistical significance in the number of finger/thumb injuries (p<0.05) (Fig.2.).

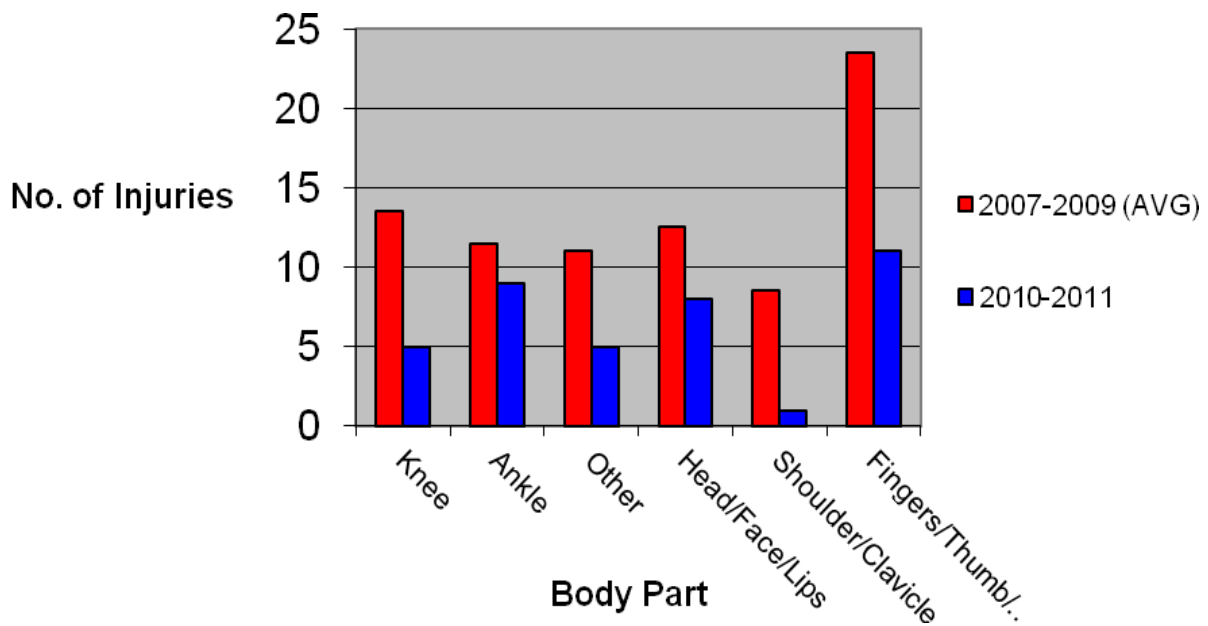


Fig 2. Injured Body Parts Comparison between the Cohorts

There was a significant reduction when comparing the total incidence rate/1000 athletic exposures and the total incidence proportion between the two cohort seasons ($p < 0.05$) (Table 2).

Cohort	Avg No. Injured Players	Avg No. Injuries	Avg No. Players Injured in League	Athlete Exposures	Total Incidence/ 1000 Exposures	Total Incidence Proportion
Historical (total)	79.5	82	9.4%	1,533,776	0.1 (95% CI: 0.1, 0.1)	10.7% (95% CI: 9.1, 12.2)
Males	71 (89%)	73 (90%)	11%	264,798	0.3 (95% CI: 0.1, 0.2)	9.8 (95% CI: 9.1, 14.2)
Females	8.5 (11%)	8.5 (10%)	7%	10,920	0.8 (95% CI: 0.3, 0.1)	8% (95% CI: 2.5, 11.7)
Pilot (total)	41	42	5.7%	335,936	0.1 (95% CI: 0.1, 0.2)	5.7% (95% CI: 4.0, 7.4)
Males	35	36	5.7%	226,920	0.2 (95% CI: 0.1, 0.2)	5.7% (95% CI: 3.9, 7.6)
Females	6	6	5.3%	10,488	0.6 (95% CI: 0.1, 1)	5.3% (95% CI: 1.2, 9.4)

Table 2. Injury Result Data

Although there was a positive trend towards a reduction in the severity of injuries and their distribution, this did not prove to be statistically significant ($p>0.05$).

Of the 838 potential participants, 638 (76%) formed part of the pilot study cohort. Twenty-four percent (200) of the players, who had initially registered through the AFI website, did not participate. Eight players (1%) refused to sign the ethics form. The authors were not able to physically meet 56 (6.7%) of the players in order to sign them up and give them the appropriate intervention. The rest (136 players or 16.2%), although registered, never paid their registration fee and did not attend the season games. Fifty-two percent (378/724) of the players reported having had at least one ankle sprain. Of these 378 players, 156 (41.3%) received ankle braces.

Seventy (45%) of the players who received ankle and mouth guards were successfully followed up post-season. Their compliance percentage values, as well as reasons provided for noncompliance are summarized in Table 3.

REASONS FOR NONCOMPLIANCE	%		COMPLIANCE RATE			
	Aircast	Mouth Guard	%	Aircast	Mouth Guard	No Pocket Rule
Forgot It	16	22	0	23.5	20	6.6
Uncomfortable	45	47	1-35	22.1	25	1.6
Other	9	0	36-70	14.7	12.5	3.3
Not in pain, so not wearing	16	0	71-99	8.8	7.5	12.8
Could not find it	0	13	100	30.9	35	75.4
Didn't feel "necessary"	13	19				

Table 3. Noncompliance Reasons and Compliance Rates

DISCUSSION

The most important finding of the present study was the reduction in finger/thumb injuries, which may be attributed to the enforcement of the no-pocket rule. As shown in Table 3, the majority of players contacted, reported 100% adherence with the no-pocket rule in the compliance questionnaire. Most players refused to purchase new shorts/pants without pockets and therefore their pockets were either glued or taped by the principle author (YK) or by themselves. Additionally, some players did not consent to taping/gluing of the pockets and some of the taped/glued pockets came undone throughout the season. The no-pocket regulation should therefore be more stringently enforced, with referees imposing harsher penalties on teams who allow their players to play with pockets.

Although the mouth guards were self-fitting in nature, most of the players did not prepare them according to the instruction sheet provided. This may partly explain the discomfort reported, as they might not have been molded properly (Table 3). In future studies, more attention should be placed on more comfortable, fitted mouth guards.

Thirty percent of the players felt that both the ankle braces and mouth guards were unnecessary, this despite strong evidence that both, significantly reduce the incidence and the severity of ankle and oral injuries respectively [4, 6, 9, 16, 23]. To assist in reinforcing the maximal, beneficial preventative effect of the braces, better education is crucial. Many players reported that they felt that they only needed to wear the ankle brace if they had an injured ankle, when in actuality, the ankle brace was intended to prevent further injury in those players with a recurrent injury and not as a treatment measure. Regular telephonic and electronic communication may further assist in player compliance throughout the season.

The purpose of the injury treatment information brochure was not achieved as there was no significant difference in the injury severity. Although all the players were given the brochure on signing the ethics form, and it was placed on the field notice board, most players did not take the time to read the brochure and discarded it almost immediately. It is suggested that the brochure be sent to all the players via electronic mail, as well as to host a series of information seminars prior to the season, to better inform the players and team captains regarding its contents. This has been successfully executed in a previous injury prevention study [28].

It was decided not to use any form of knee bracing to prevent injury even though 83% of injuries to the knee in the historical cohort study were extrinsic in nature. Research is limited on the use of knee braces (prophylactic and functional) to potentially prevent knee ligament injury in the non-injured population [27]. Knee braces have not to date proven to be effective in reducing the number and severity of knee injuries [19, 26]. There is evidence, however, that neuromuscular preventative programmes have been shown to reduce the incidence of non-contact knee injuries [1, 20, 25, 31], although they have yet to be investigated in reducing injury risk in contact-type sports.

Although 11% of the injuries in the historical cohort study were to the shoulder region, no shoulder injury prevention methods were implemented. Other than changing game rules to reduce the incidence of player-on-player contact, previous attempts to reduce the impact of shoulder injuries by the use of pads, have proven unsuccessful. The pads appear to "bottom out" under higher-impact loads and therefore offer little protection when the athlete may need it most [10, 18].

In order to achieve a higher level of evidence based study, it would have been preferable for the study cohort to have been randomised into those who received the prevention measures and those who did not. This was not possible for numerous reasons. As the AFI is an amateur league, with no team coaches to monitor the interventions used, there existed the risk of the unplanned crossover effect, whereby players assigned by the randomisation to the control group may begin to have second thoughts and may decide, of their own accord, to wear the intervention measures provided. This phenomenon would pose a serious challenge in the analysis of the data [8]. As a result of the current evidence that both ankle braces and mouth guards may significantly reduce the incidence and severity of ankle and oral injuries respectively, the ethics committee of the Meir Hospital, Kfar Saba did not approve of the randomisation of the study cohort.

As captain/management and player-compliance are regarded as important factors in any prevention trial, certain key prevention ideas were not accepted by the AFI management, even though they could potentially be important injury prevention methods. These included headgear and changing the blocking nature of the game. Headgear, for example has been shown to reduce the force of non-ball-related impacts to the head [21, 22]. On analysis of the mechanism of injuries, and contact between players, blocking in particular was a significant cause of injuries (Fig.3.).

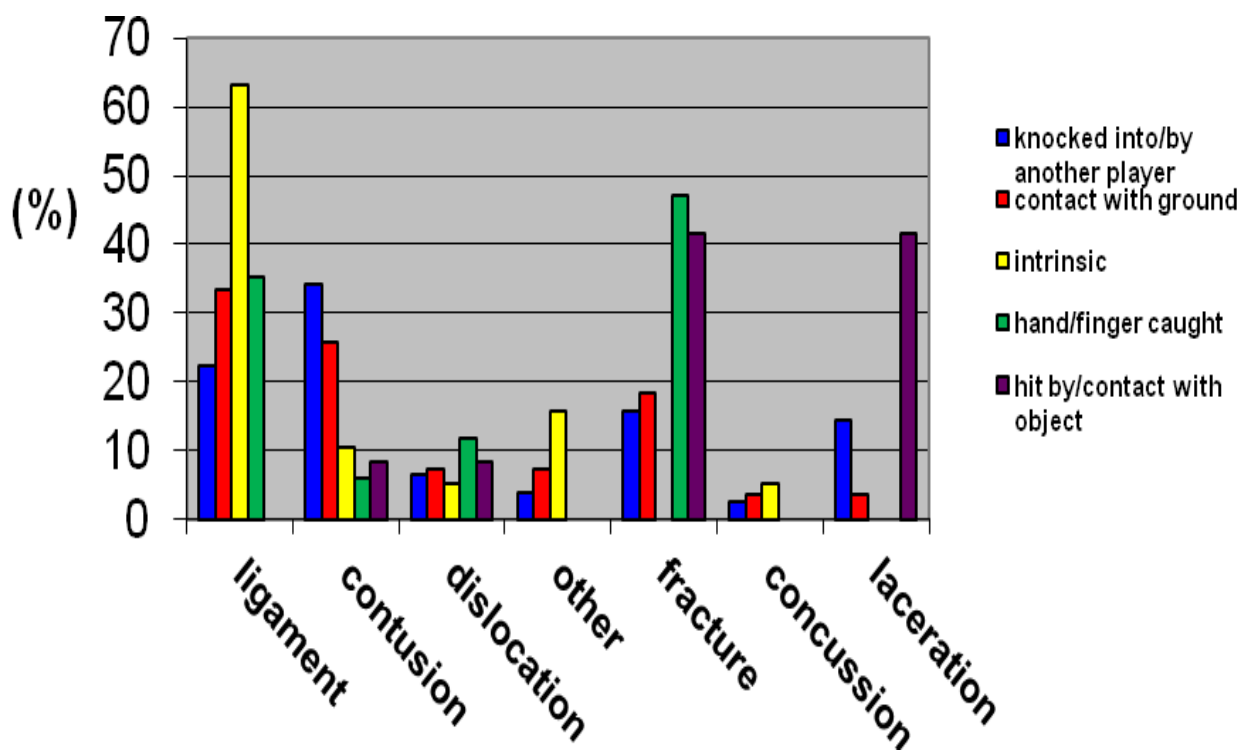


Fig 3. Injury Type vs. Injury Mechanism

Although chop blocks or blocks below the waist are not allowed, defensive players can get in the path of an offensive player in an attempt to grab the flag. Preventing or further limiting contact

between players by changing the blocking rules of the game could reduce the incidence and severity of these injuries. As a member country of the International Federation of American Football (IFAF), the AFI management is bound by their rules and therefore did not agree to deviate from the rules on blocking set out in International Flag Football Rules [12].

Limitations of the study included the possibility of the underreporting of injuries by the players themselves. This may have been due to players being injured towards the end of the game, not wanting to report their injuries for personal reasons, as well as the refusal of some to comply with the questionnaire or their subsequent unreachability. The study included a specific-age population (pre-college male and female students) and therefore the possibility exists that the injury rate may be different in older or younger athletic populations. Although a telephonic, in-depth questionnaire was administered by the principal author within a day or two following the injury, there were cases where the player's condition necessitated a follow-up medical investigation, and therefore a final diagnosis was only made 7-14 days post-injury. Although the authors felt that this time period was short enough that players would not suffer from recall bias, the possibility still existed. Finally, this was a pilot study, with its limitations of time and methodological shortcomings. A longer, prospective injury prevention study, utilizing the above mentioned measures is recommended.

CONCLUSIONS

This is the first known prevention study in American Flag Football and has provided preliminary evidence that finger/hand injuries can be significantly reduced in flag football. This study may serve as a paradigm for future programmes. Further development of prevention strategies is needed. This should involve the strict enforcement of the no-pocket rule and wearing the appropriate head gear. The authors suggest that in future studies, the mouth guards should be individually prepared for the players during the distribution process. The IFAF should consider making the use of mouth guards mandatory during play, and not only a recommendation as it presently is in accordance with International Flag Football Rules [12]. In an effort to further increase player compliance in future studies, several types of ankle braces should be tested prior to their distribution. The authors additionally recommend a trial period prior to any intervention, in order to ensure maximum comfort and therefore ensuring better compliance.

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CHAPTER 4

INJURIES CAN BE PREVENTED IN CONTACT FLAG FOOTBALL!

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Knowledge is hard won, in which we have more
confidence than we have in opinion, hearsay,
and disbelief''

- Peter Medewar

ABSTRACT

Purpose: This original prospective cohort study was conducted in an attempt to significantly reduce the incidence and the severity of injuries in an intervention cohort as compared to a two-season historical cohort, and to provide recommendations to the International Federation of Football (IFAF) pertaining to prevention measures to make the game safer.

Methods: 1260 amateur male (mean age: 20.4 ± 3.9 yrs) and 244 female (mean age: 18.5 ± 1.7 yrs) players participated in the study. Four prevention measures were implemented: The no-pocket rule, self-fitting mouth guards, ankle braces (for those players with recurrent ankle sprains) and an injury treatment information brochure.

All time-loss injuries sustained in game sessions were recorded by the off-the-field medical personnel and followed up by a more detailed phone injury surveillance questionnaire.

Results: There was an 54% reduction in the total number of injuries, and a significant reduction in the incidence rate and incidence proportion between the intervention cohort as compared to the historical cohort ($P < 0.001$). There was no statistically significant reduction in the number of injuries in any of the body parts, except for in hand/wrist injuries related to the use of pockets ($p < 0.001$), as well as the severity of mild-moderate injuries ($p < 0.05$).

Conclusions: This study provided evidence that hand/wrist injuries can be significantly reduced in flag football. Recommendations to the IFAF include strict enforcement of the no-pocket rule, the use of soft headgear, comfortable-fitting ankle braces and mouth guards and additionally, to change game rules concerning blocking.

Level of evidence: II

Key Terms: Contact flag football, Sports injuries, Prevention, Intervention

INTRODUCTION

The implementation of evidence-based methods to prevent sports injuries is critical due to the possibility of preventing a substantial proportion of these injuries [7,19,24]. American flag football (AFF) is a modified version of tackle football without significant physical contact. In place of tackling the ball carrier, flags that are clipped to a belt worn around the waist, must be removed. The removal of at least one of the flags is equivalent to a tackle and ends the play [11].

In a study conducted on American army recruits, AFF resulted in the third highest incidence of injuries in the sports and recreation category, following basketball and softball [4]. Despite its lessened physical contact and injury susceptibility as compared to tackle football, AFF produces a relatively high injury incidence [4,6,24], and there has been no prospective, longitudinal study reported in the literature that has examined the impact of interventions to reduce the incidence of these injuries.

Previous studies in flag football have shown a high percentage of anatomical specific injuries; the hand/wrist (16-34%), the knee (11-18%), the ankle (8-17%), the face and head (18-29%), and the shoulder (9-10%) [4,6,15,16]. Direct trauma was responsible for the vast majority of injuries (64-75%).

During a previous prospective epidemiological study conducted during the 2007-9 playing seasons (Historical cohort), almost all players wore pants with side pockets and refrained from playing with

mouth guards [15]. Despite the available evidence illustrating that mouth guards provide impact energy attenuation and limited prevention against concussions [2,5, 7,21], the use of mouth guards is not enforced in the sport of contact flag football. Furthermore, in the historical cohort, 40% of the hand/wrist injuries were reported as a direct result of fingers being caught in the pockets of the opposing players' pants (Fig.2) [15]. Although ankle braces have proven to be successful in reducing ankle injuries in sports, primarily in those players with recurrent sprains, very few players in the historical cohort used them [17,24]. There have been no studies published regarding the role of ankle braces in American flag football.

A pilot injury prevention study in flag football has been conducted [16]. The study provided preliminary evidence that hand/wrist injuries can be significantly reduced as well as important information that aided in refining research methodology for this present prospective prevention study.

The hypotheses of this study included:

1. The enhanced awareness of safety due to the study would lead to a significant reduction in the total incidence of injuries.
2. Adherence to the no-pocket rule would significantly reduce the incidence of finger injuries, as compared to the historical cohort.
3. Mouth guards would reduce the severity of concussions and oral injuries, as compared to the historical cohort.
4. There would be a significant reduction in re-injury amongst players with recurrent ankle sprains if they wore ankle braces, as compared to the historical cohort.

This intervention study is the first prospective injury prevention study in flag football. The authors consider that the primary long term goal of any prevention study should be how the outcomes of the efficacy research can be translated into actions that can actually be implemented in the real-world context of on-field sports behaviours. To realize this goal, they planned to implement the study recommendations initially on a local sporting level and then to inform the International Federation of American Football (IFAF) of the findings of the study. The intention would be to make changes in the international rules, thus making flag football a safer sport for all involved.

MATERIAL AND METHODS

A two-season longitudinal, prospective injury prevention study was conducted over the 2011-2013 playing seasons. The cohort was comprised of post high school American and Canadian males and females who were studying abroad in Israel for a year. All participants had joined the flag football league of their own accord and teams were formed in Israel. Participants were of similar age, socio-economic background (had similar levels of education and were from the same ethnic communities) and played a similar number of games during the league season as those in the historical cohort (Table 1.) A time-loss injury was defined as an injury that resulted in a player being unable to return to the current or future game [8]. All game sessions were played on a synthetic grass surface. The above injury definition and reporting mechanism was the same as that used in the historical cohort.

Following agreement with the management of the AFI, four intervention measures were implemented for the intervention cohort:

- V. The no-pocket rule.** Players were not permitted to play with pants which had open side pockets. Unlike the pilot study protocol, players were not permitted to glue or tape their pockets.
- VI. Self-fitting mouth guards (Everlast™ double Mouth Guard).** Prior to the first game of the season, all players were fitted with individually-moulded mouth guards. Referees did not allow players to participate in the game sessions without mouth guards.
- III. Ankle braces (Universal Ankle Stirrup DJO™).** One hundred and eighty-seven ankle braces with fitting instructions were distributed to 153 (10.2%) players. These players had reported a history of at least two previous sprains on the ipsilateral ankle with accompanying subjective functional instability within the previous five-year period. Some players had bilateral instability and therefore received a brace for each ankle.
- IV. An injury treatment information brochure.** In an attempt to reduce the severity of the injuries, the brochure provided information on how to effectively treat an injury in the acute phase (P.R.I.C.E. method), as well as information pertaining to medical facilities available to the players in the event of an injury [3,14]. Upon signing the consent form, the brochure was handed out individually to each player, as well as sent to their electronic mail addresses. Injury severity is defined as the number of days that had elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection [8].

As a result of the AFI's amateur league status, there are no official league practice sessions held during the season. This fact also precluded a pre-participation examination of each of the participants with appropriate follow-up therapeutic measures. League registration is done only online, and there is no way of knowing until the league commences, how many players will be involved. All teams play a one hour game per week. Injured players were either referred by the attending medic to their local

physician or sent to the emergency unit of a local clinic or hospital. The attending physicians were requested to provide a specific written diagnosis or to use a sport specific injury coding system, such as the Orchard system [22]. This was done in order to reduce the risk of misclassification of injury.

Time-loss injuries were recorded by the attending paramedics throughout the playing season. They were then collected manually by the principal author (YK) following the conclusion of all games that were played on that day. A telephonic, in depth injury-surveillance questionnaire was subsequently conducted within two days, following the injury. This questionnaire was based on the recommendations of the internationally accepted consensus injury-surveillance questionnaire of Fuller, et al. [8] and was further adapted for AFF. Injuries which occurred outside of game play, were not included. Following the collection of the exposure data, the injury rates were calculated using incidence rate (IR)/1000 athletic exposures and the total incidence proportion (IP) [18].

Upon the termination of the study, all players who received ankle braces were contacted telephonically and surveyed about their ankle brace, mouth guard and no-pocket rule compliance. In order to examine the overall baseline demographic data of the injured players, as compared to the non-injured cohort, an internet-based random number generator (random.org) was used in a random cohort of 60 non-injured players who were questioned with regards to their compliance with the no-pocket rule and adherence to wearing mouth guards.

Prior to signing the informed consent form, each participant was given a brief explanation about the study. Helsinki approval (No. 0052-11-MMC) was obtained by the medical ethics committee of the Meir Hospital, Kfar Saba, Israel

STATISTICAL ANALYSIS

In order to compare quantitative variables between the two cohorts (demographic as well as physical characteristics), the independent samples two-tailed t-test for equality of means was used. Comparison of qualitative variables between the historical and intervention cohorts was executed by means of the Pearson chi-square test. Statistical analysis was undertaken via the use of SPSS® predictive analytics software package (version 18.0), as well as the WinPepi package of statistical programmes (PEPI-for-Windows) (version 11.18).

With the assistance of the "Power and Precision" statistical power analysis software package, the calculation of an appropriate sample size for the planned study was computed. In order to yield a power of 80% and N=1400, to prove that the difference between the groups is statistically significant, the 11% injury incidence rate (from the historical cohort) would have to be reduced to 9% as a result of the intervention programme. In order to prove that a significant decrease in finger injuries, assuming a 5% significance level, a power of 80% and N=1400, at least a reduction from 17.5% to 15% needs to be achieved, if the significance level is one-tailed, and at least a reduction from 17.5% to 14.7 %, if the significance level is two-tailed. In order to prove that a significant decrease in ankle injuries occurred, assuming a 5% significance level, a power of 80% and N=1400, at least a reduction from 13.5% to 11.3% needs to be achieved, if the significance level is one-tailed. There needs to be at least a reduction from 13.5% to 11 %, if the significance level is two-tailed. The p-value of statistical significance was 5% or less.

RESULTS

There was no significant difference between the cohorts regarding demographic data ($p < 0.05$) (Table 1). Of the total 1504 players who played in the 2011-13 seasons (intervention cohort), 1257 (83.6%) participated in the study. Ninety-four (7.5%) players did not play. The authors were unable to make contact with 153 (12.2%) players.

When comparing the two cohorts, the intervention study resulted in a 52% (86/164) reduction in the total number of injuries, as well as a statistically significant reduction in the total incidence rate (IR)/1000 athletic exposures ($p < 0.001$) and the total incidence proportion (IP) ($p < 0.001$) (Table 1). Table 2 represents the incidence rates between the cohorts in relation to the specific injuries. There was a statistically significant reduction in the number of hand/wrist injuries that resulted from the fingers/thumb having been caught in the opposing player's pockets, ($p < 0.05$). There was a non-significant (N.S) reduction in the incidence of injuries in the shoulder and the knee regions. Although there was a 40% reduction in ankle injuries, this was N.S. No player who received and played with an ankle guard re-injured his ankle.

Cohort	Historical	Males	Females	Intervention	Males	Females
No. Games	1028	846	182	821	671	150
No. Teams	144	116	28	115	92	23
No. Players	1412	1186	225	1257	1053	203
Avg Age (yrs) SD	20.7 5.3	20.5 4.9	22.4 7.6	20.4 3.9	20.5 3.9	18.5 1.7
Avg Height (m) SD	1.7 0.1	1.8 0.2	1.7 0.9	1.76 0.09	1.8 0.1	1.66 0.1
Avg weight (kg) SD	78.9 17.2	80.7 16.9	62.6 9.2	82 15.5	82.9 15.3	63.6 3.0
No. Injured Players	159	142 (89%)	17 (11%)	86	82 (95%)	4 (5%)
No. Injuries	164	145 (90%)	19 (10%)	86	82 (95%)	4 (5%)
Athlete Exposures (AE)	1,533,776	1,059,192	43,680	1,031,997	706,563	30,450
Incidence Rate(IR)/1000 Athlete Exposures	0.11 (95%CI:0.09,0.13)	0.14 (95% CI:0.12, 0.17)	0.39 (95% CI: (0.18, 0.55)	0.83 (95% CI: 0.07,0.10)	0.12 (95% CI: 0.09,0.14)	0.13 (95% CI: 0.003,0.26)
Incidence Proportion (IP) (%)	10.66 (95%CI:9.61, 2,91)	11.26 (95% CI:10.13, 13,83)	7.49 (95% CI:4.64,10.91)	5.07 (95% CI: 5.45, 8.24)	7.79 (95% CI: 6.17, 9.40)	1.97 (95% CI: 0.06,3.88)

Table 1. Demographic and Injury Result Data

AE= athlete-exposure is defined as the number of games played per individual athlete

IR = occurrence of new cases per unit of person time

IP = the number of injured athletes divided by the number of athletes at risk during a specified time period²⁷

Injury Type	Historical cohort	Intervention cohort
Knee ligament injuries	(N=10) 0.01 (95% CI: 0.003, 0.01)	(N=10) 0.01 (95% CI: 0.003,0.01)
Ankle Sprains	(N=20) 0.01 (95% CI: 0. 01, 0.02)	(N=14) 0.01 (95% CI: 0.01, 0.02)
Head/Face injuries (concussions, fractures, lacerations)	(N=25) 0.20 (95% CI: 0.01, 0.02)	(N=15) 0.01 (95% CI: 0.01.02)
Fingers (fractured/sprains/dislocations)	(N=22) 0.02 (95% CI: 0.01, 0.02)	(N=12) 0.01 (95% CI: 0.004, 0.01)
Other (Chest, wrist, shoulder, clavicle, lower leg, elbow, hip, contusions)	(N=84) 0.06 (95% CI: 0.05, 0.07)	(N=35) 0.02 (95% CI: 0.02, 0.03)

Table 2. Incidence rates in relation to the specific injuries.

There was a significant difference with regard to the injury severity in the head/ face region (Fig.1) ($P<0.05$). The values in the bars in Fig. 1 represent the percentages of the total number of injuries per anatomical region. Overall, there was a significant difference between the cohorts with regard to the severity of injury ($p<0.05$). In the historical cohort, 34% (56/164) of the injuries were defined as either minimal-mild, while 63% (104/164) were moderate-severe. In the intervention cohort, 17% (15/86) of the injuries were defined as either minimal-mild, while 83% (71/86) were moderate-severe. The compliance rates and reasons for non-compliance for the intervention cohort are summarized in Table 3.

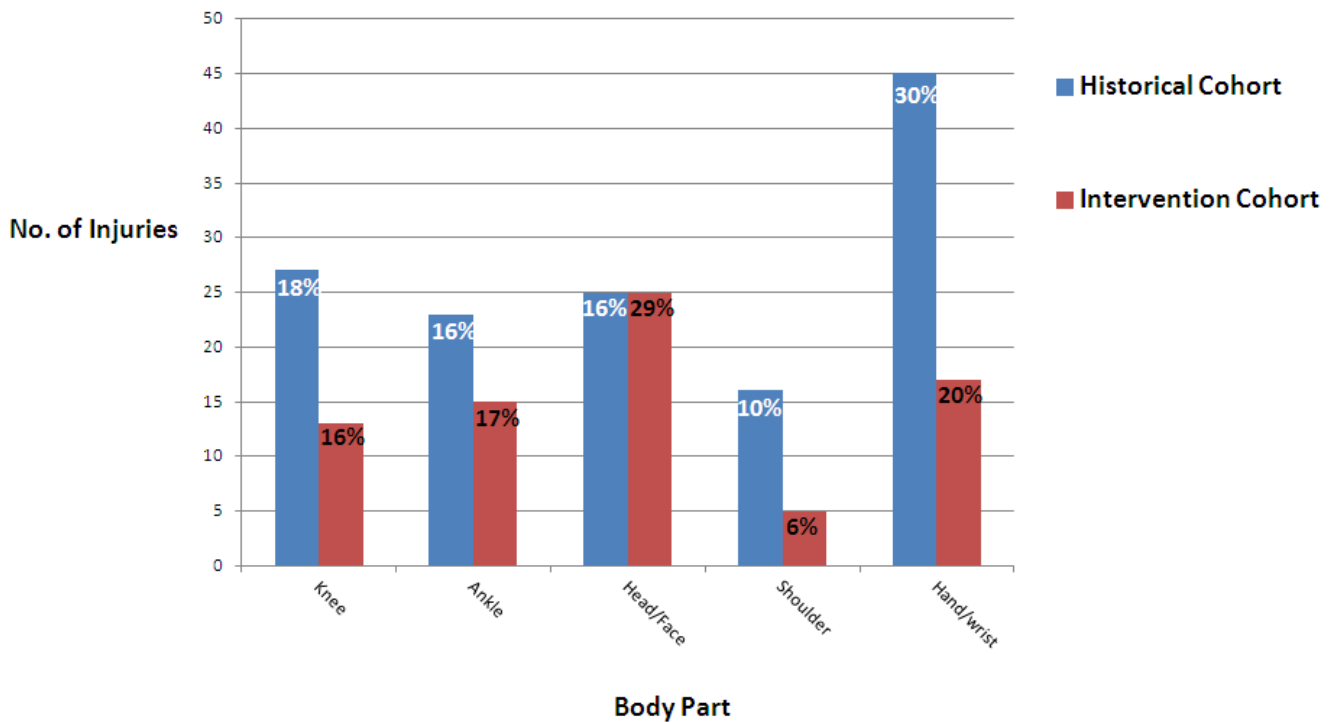


Figure 1. Number of Injuries vs. Injured Body Part

REASONS FOR NON-COMPLIANCE (2011-2013)	Ankle Guard (%)	Mouth Guard (%)	COMPLIANCE (%)	Ankle Guard n=50	No-pocket Rule (Total) n=68	Mouth Guard (2011-2012) n=32	Mouth Guard (2012-2013) n=35	Mouth Guard (Total) n=67
Forgot it	24.2	30.4	0	18	0	15.6	0	7.5
Uncomfortable	36.3	39.1	1-35	16	1.5	25	0	11.9
Other	15.2	13.1	36-70	30	2.9	12.5	0	6
Not in pain, so not wearing	6.1	0	71-99	2	8.8	9.4	8.6	8.9
Lost it	6.1	17.4	100	34	86.8	37.5	91.4	65.7
Didn't feel "necessary"	12.1	0						

Table 3. Non-Compliance Data and Compliance Rates

DISCUSSION

The most important finding of this prevention study was the significant reduction in both the injury incidence rate (IR) and incidence proportion (IP) between the historical and the intervention cohorts (Table 1). This provides convincing evidence that the combination of intervention methods employed had a positive impact on reducing the injury statistics in the intervention cohort.

In the intervention cohort, there were no injuries that resulted from fingers being caught in the opposing players' pockets. This can be compared to hand/wrist injuries in the historical cohort, of which 40% were caused by pockets (Fig.2)[15]. Thus, the no-pocket rule proved beyond reasonable doubt that it is a significant factor in reducing hand/wrist injuries in flag football.

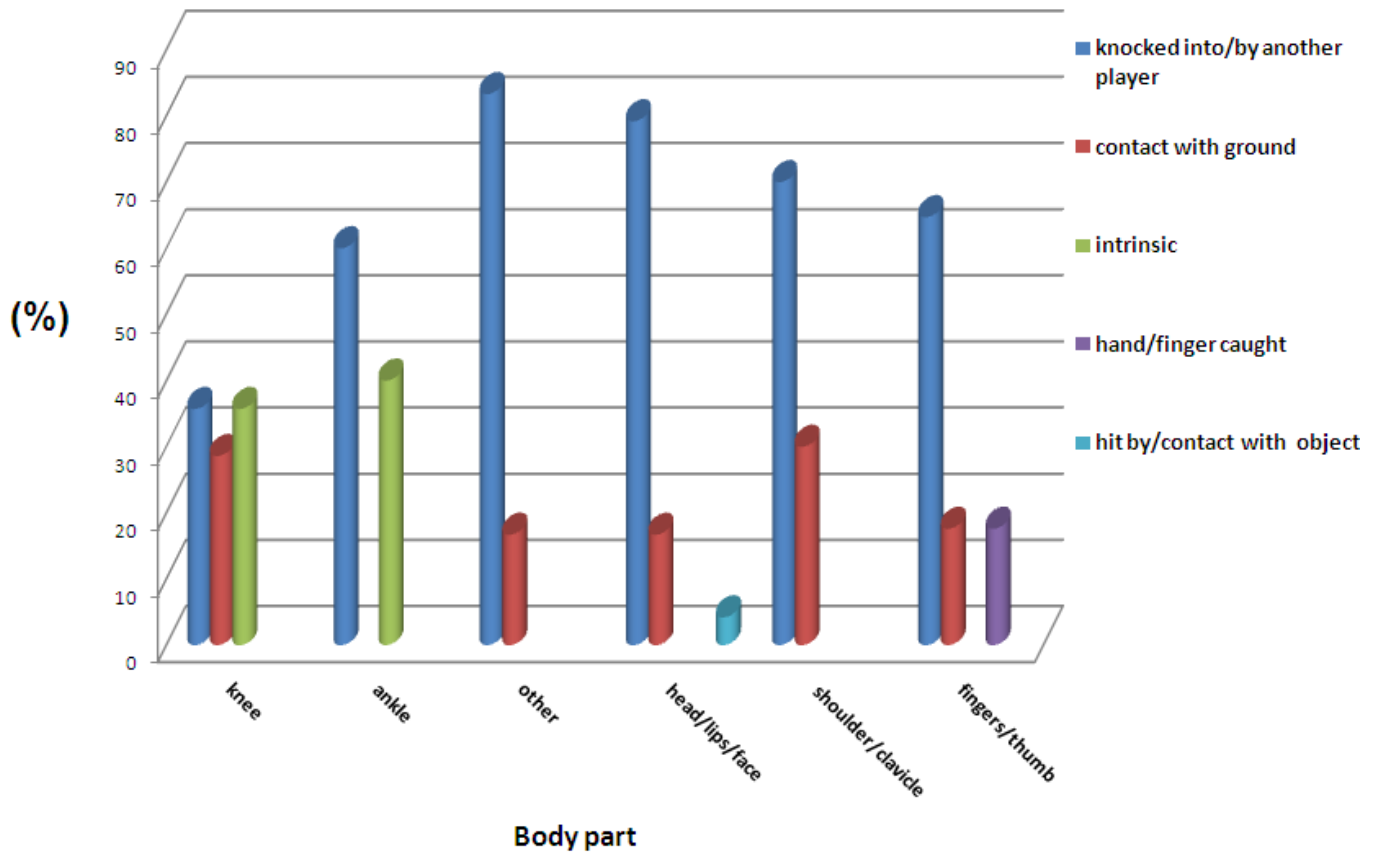


Figure 2. Body part vs. Injury mechanism in the historical cohort

At the very outset of the study, the authors of this study made a concerted effort to convince the AFI league management and medical staff to be active promoters of this prevention project. It is the authors' experience that a successful symbiotic relationship between researchers and sport management personnel, will determine to a great extent the eventual success of prevention programmes. In the final season of this study (2012-2013), teams were penalized if any player was found playing with open pockets or without a mouth guard. The inclusion of penalties is a possible contributing factor to the increase in compliance percentage, compared to the previous season (Table 3). The permanent institution of proven intervention methods should therefore serve as a primary goal in any prevention study. Previous prevention trials have shown that when successful

intervention methods are discontinued, injury incidence rates return to their previous levels [20]. Although International Flag Football Rules (Section 3. Article 1. Mandatory Equipment) lists the no-pocket rule as mandatory, there are no listed penalties for any player violating the rule. In addition, mouth guards are only recommended for national competition games [12].

Seventy-five percent of the reported head and face injuries, as well as 62% of the finger and wrist injuries were as a result of players knocking into one another during blocking or direct collision. Certain key injury prevention interventions, including changing blocking rules and wearing soft headgear were not accepted by the AFI management, although the implementation of such interventions could possibly have provided significant evidence with regard to injury prevention in contact flag football. As a member of the International Federation of American Football (IFAF), the AFI management is bound by IFAF rules and therefore refused to alter any rules regarding blocking as set out in International Flag Football Rules[12].

The finding that no player who had received and played with an ankle guard re-injured his ankle is of significance as recurrent injury has been reported to be a significant predictor for re-injury [10,17]. Twelve percent of the players (Table 3) who had reported ankle instability, felt that ankle braces were unnecessary despite strong evidence that ankle braces significantly reduced the incidence and the severity of ankle injuries[10,17]. The literature reports ankle sprain incidence in various sporting activities between 15–73%, which is influenced by factors including sporting type, playing frequency, age, gender and previous injury [10,17].

Although 18% of injuries in the historical cohort and 16% in the intervention cohort involved the knee region (Fig.1.), research is limited on the use of knee braces (prophylactic and functional) to potentially prevent knee ligament injury in a non-injured population [1]. Knee braces have not to date proven to be effective in reducing the number and severity of knee injuries.

Although all of the players were given the brochure upon signing the ethics consent form, as well as it being affixed on the field notice board, and available on a freely available online module, most players did not take the time to read the brochure. Many admitted discarding it almost immediately. A possible method for neutralizing this drawback would be to host a series of information seminars during the pre-season to better inform the players and team captains regarding the brochure's contents. This has been successfully executed in a previous injury prevention study [25].

In order to have achieved a higher level of evidence in the study, it would have been preferable for the intervention study cohort to have been randomized into those who received the prevention measures and those who did not. Whilst randomized controlled trials are theoretically ideal, they are hard to conduct - particularly taking into account the broad safety culture of a sport and the safety behaviours of its participants [7]. This was not possible for numerous reasons. As the AFI is an amateur league with no team coaches to monitor the interventions used, there existed the risk of an unplanned crossover effect, whereby players assigned by the randomization to the control group could have had second thoughts and decided of their own accord, not to utilize the intervention measures provided. This phenomenon would have posed a serious challenge in the analysis of the data and undermined the very experimental design [9]. Pasanen et al [23] showed in a cluster

randomized trial comprising female footballers, that randomization in sports injury prevention is possible, with good intervention results.

Other limitations of the study included the possible underreporting of injuries by the players themselves. This could be due to players being injured towards the end of the game and not wanting to report their injuries for personal reasons, including "hiding" the injury from their captains and league officials. Although a telephonic, in-depth questionnaire was administered by the principal author within two days following each injury, there were cases where the player's condition necessitated a follow-up medical investigation, and therefore a final diagnosis could not be made until 7-14 days post-injury. Although the authors felt that this time period was short enough that players would not suffer from recall bias, the possibility still existed.

Examining the effect of more than one or two interventions at a time, may have made it more difficult to determine the effect of each individual intervention. The authors therefore used only one intervention to reduce the incidence of injuries for each body part.

As stated previously in this paper, due to the amateur nature of the AFI , there are no official league practice sessions held during the AFI season and registration is done only online. Pre-participation examination for each of the participants was therefore precluded. The injury questionnaire used in this study did in fact contain questions pertaining to previous injury, and this was taken into account when the prevalence of injuries was calculated. This however was retrospective in nature, and player recall bias may have resulted in inaccuracies.

Co-intervention bias or attention effect may explain part of the positive reduction in injuries in the intervention group, not related to the four intervention actions. Although there were a similar number of players in the two cohorts, there were approximately 200 more games played in the historical cohort. This may have allowed for more opportunities for injuries to occur.

CONCLUSION

This is the first prospective prevention study in American contact flag football and has provided convincing evidence that finger/thumb injuries can be significantly reduced in flag football. Based on the results obtained, recommendations to the IFAF include the mandatory use of mouth guards, and the strict implementation of the no-pocket rule, including harsh penalties for their violation. In addition, comfortable-fitting ankle braces, the use of soft headgear and changing the blocking rules, should be considered.

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CHAPTER 5

GENERAL DISCUSSION AND CONCLUSIONS

"How can we remember our ignorance, which our growth requires, when we are using our knowledge all the time?"

- Henry David Thoreau

Realization of study goals

The principal purpose of this doctoral study was to conduct an injury prevention study in contact flag football, with the aim of reducing the incidence and severity of injuries in this fast-growing amateur international sport. A second aim was to ensure that if the intervention methods introduced were indeed successful in reducing the incidence and severity of injuries, they would remain as permanent features of the AFL league rules of play. A further extension of this second aim, was to inform the International Federation of American Football (IFAF) of the findings of the study, with the intention of changes being made in the international rules, thus making flag football a safer sport for all involved.

All purposes were successfully achieved:

1. When comparing the two cohorts, the intervention study resulted in a 52% (86/164) reduction in the total number of injuries.
2. There was a trend towards a reduction in the number of injuries in all body parts, reaching statistical significance in hand/wrist injuries related to the use of pockets ($p < 0.001$). There was a significant reduction in the severity of mild-moderate injuries ($p < 0.05$).
3. The no-pocket rules as well as the mandatory use of mouth guards, have become permanent rules in the AFI league.
4. Recommendations have been sent to the IFAF (Chapter 6).

The most important finding of this prevention study was the significant reduction in both the injury incidence rate (IR) and incidence proportion (IP) between the historical and the intervention cohorts. This provides convincing evidence that the combination of intervention methods employed had a positive impact on reducing the injury statistics in the intervention cohort.

The permanent institution of proven intervention methods should therefore serve as a primary goal in any prevention study. There were no injuries in the intervention cohort that resulted from fingers being caught in the opposing players' pockets. This can be compared to hand/wrist injuries in the historical cohort, of which 40% were caused by pockets. Thus, the no-pocket rule proved without any doubt that it is a significant factor in reducing hand/wrist injuries in flag football.

The trend towards a reduction in the number of injuries in all body parts may possibly be explained by the general atmosphere created by the study's staff members being present at all games, both on the players as well as the referees. This may have contributed to enhanced awareness of safety while playing, leading to the significant reduction in the total incidence of injuries.

Although there was a decrease in the severity of minimal-mild injuries, the contribution of the injury-treatment information brochure remains unclear. Although all of the players were given the brochure upon signing the ethics consent form and it was placed on the field notice board, most players did not take the time to read the brochure and discarded it almost immediately. A possible method for neutralizing this drawback would be to host a series of information seminars during the pre-season to better inform the players and team captains regarding the brochure's contents.

Lund J, Aarø L, 2004¹ reinforced the Van Tiggelen D et al, 2008² model by proposing that in order to find a strong path in the injury prevention, programmes implementing structural modifications such as regulations, enforcement methods, environmental and product modifications should be introduced, rather than behavioural modifications. In order to achieve this, and for the first time in the 25 years of the AFI league's history, the use of mouth guards and the no-pocket rule become obligatory league rules and were vigorously enforced. In the final season of this study (2012-2013), teams were

penalized if any player was found playing with pockets or without a mouth guard. Certain key injury prevention interventions, including changing blocking rules and wearing soft headgear were not accepted by the AFI management, although the implementation of such interventions could possibly have provided further significant evidence regarding injury prevention in contact flag football.

The value of the pilot study

The pilot study (Chapter 3) was the first attempt to prevent injuries in contact flag football. Much valuable information was gained, that not only assisted during the planning process of the final intervention study (Chapter 4), but may also provide valuable insights for future researchers, thus avoiding pitfalls and mistakes. The major findings from this pilot study (from the compliance results) were that mouth guards should be individually prepared for the players during the distribution process and that ankle braces should be tested prior to their distribution, including a trial period prior to any intervention. Both of these issues had a major influence in the player compliance rate. This pilot study fits in well with steps 3 and 4 of the modification to Van Mechelen's model³ proposed by Van Tiggelen D et al, 2008.¹

Efficacy measures how well preventative measures work in clinical or intervention trials⁴ or alternatively, when the scientific efficacy of a preventative measure has been proven, it then may be considered for implementation by the stakeholders (e.g. sports federations, team managers).¹

In this flag football study, once the intervention methods were initially proposed, the pilot study was conducted to establish the efficacy of the preventative measures. The lessons learnt from this study enabled changes to be made for the 2-season intervention study, which then enabled the establishment of the efficiency of the protective measures as well as the compliance and risk-taking behaviour (as described in steps 5 & 6 of the Van Tiggelen D et al, 2008 model.¹

Published details of pilot studies also assist to refine or modify the research methodology, this in order to assess the feasibility of large full-scale comprehensive studies. Finally, as Thabane L et al, (2010)⁵ so succinctly summarized their importance – "they should be scrutinized the same way as full scale studies, and every attempt should be taken to publish the results in peer-reviewed journals".

Study follow- up

Another aspect of the successful implementation of prevention programmes is the continual follow up once the research study has been completed. Too often, successful prevention projects are completed but without further follow up, and the injury incidence amongst the sporting teams/ leagues returns to the previous figures. This is a great pity and greater efforts must be instituted to avoid this occurring. Myklebust and her colleagues⁶ published a paper recently showing how following the completion of their very successful prevention study in female handball players, the incidence of injuries in their study population returned to at least as high as before the intervention started. Interviews with the players injured during this period also revealed that few of their teams were using the prevention programme. They further realized that the promising findings from their ACL Injury Prevention Study, did not result in the programme being implemented as a regular part of the training by coaches or players. Their main recommendations therefore include taking advantage of the coach as a key partner.

Several studies and reviews have documented that injuries can be prevented if programme compliance is sufficient.^{7,8,9} Our experience differed somewhat from the Myklebust et al findings. Our study highlights the fact that making the interventions mandatory in the rule book, does not necessarily have much impact on player compliance (mouth guards, no pocket rule). The turning point in our study was the imposition of penalties for non-compliance in the 2012-2013 playing season. Player, coach and team compliance may be influenced by factors such as the comfort and ease in

which interventions are applied, making safety a major motivator for their core business, thus ensuring that the methods are directly relevant to the particular sport. Although the no pocket and mouth guard interventions in our study are now permanent rules in the AFI league and the study has been completed, the AFI management has agreed to participate in a follow-up study over the next 2 seasons, to see whether the positive results gained from the intervention study will be maintained. This serves as a further test to determine whether the rule changes and penalties introduced will remain a permanent feature of the game of flag football, thereby ensuring a continued reduction in injury incidence, thus making the sport safer for all future generations of players.

Injury comparison with other sports

Almost all team sporting activities involve some form of player-on-player contact. Tackling, in one form or another, is a major part of many popular games (for eg. soccer, rugby, American football), whereas in others, it is prohibited (Flag football, field hockey, basketball). As a result, the epidemiology of sporting injuries are variable, resulting in sport-specific injuries. Prevention programmes need to be sport-specific, although there are numerous injury mechanisms that may be compared (eg. ankle sprains) and therefore successful prevention programmes may be the similar. Table 1. represents the anatomical injury distribution between three popular sporting activities that do indeed allow contact, but prohibit tackling.

Sport	American Flag Football	Field Hockey	Basketball
Authors	Kaplan et al, 2012¹⁰	Eggers – Stroder et al, 1994¹¹	Borowski LA et al, 2008¹²
Head/face	16%	34%	13.6%
Lower Limb(excl. Ankle)	19%	21%	8.4%
Upper Limb	32%	14%	9.6%
Ankle	14.3%	15%	39.7%
Other	18.7	16%	28.7%

Table 1. Anatomical Injury distribution between common non-tackle sports

Table 1. reveals that even when comparing contact, but non-tackle sports, there exists a wide variation in the anatomical distribution of injuries. On further analysis of the table, it becomes apparent that head/face and lower limb injuries (excluding the ankle) are far more common injuries in field hockey, as compared to AFF or basketball.

Field hockey is a popular sport that is played throughout the world. Most of the literature on the sport has focused on describing injury patterns.¹¹ Studies also suggest that men have a higher rate of injury and that they experience severe injuries more often than women. These severe injuries include trauma to the head, face, and upper limb and usually are the result of contact with the stick or ball.¹³ Consequently, many authors suggest that all players wear face and hand protection. Current International Field Hockey Federation rules recommend minimal protective equipment (e.g.,

mouthguard, shin, and ankle guards), and surveys indicate that many players do not wear mouthguards regularly.¹³ Interestingly enough, in the epidemiological study undertaken by Kaplan et al, 2012¹⁰, similar findings were found. Although mouth guards in particular have been shown to prevent oral and tongue injuries and may reduce the severity of concussions,^{14,15} very few players in the study cohort used them, despite the fact that their usage is recommended according to International Flag Football Rules.¹⁶

In another epidemiological study on field hockey injuries¹⁷, finger/thumb fractures alone accounted for almost 15% of severe game injuries, and most of these were caused by contact with the ball or stick. In the epidemiological study undertaken by Kaplan et al, 2012¹⁰, finger/hand injuries comprised 30% of the total incidence of injuries. Field hockey players may be more prone to hand injuries than players in some other sports because of selected inherent aspects of the game.¹⁷ In field hockey, the bent-over posture is used for dribbling and shooting the ball. This posture may place the player's hands (the head and face, too) closer to the ground, which may make it easier to sustain trauma from other players' sticks or cleats or a ball during normal play. In areas of congestion, such as in front of and near the goal, players may easily have their hands crushed between 2 sticks, a player and a stick, or a player and the ground, which led players to use the stick to "trap" the ball against the ground to stop it. This technique may still be used in other parts of the game and puts the hands and fingers at considerable potential for injury. Large, full-coverage gloves, such as those worn by ice hockey and men's lacrosse players, are not feasible in field hockey because they may negatively affect the grip and stick-handling ability. However, close-fitting, posteriorly padded gloves are an option that could potentially prevent some finger and hand injuries in field hockey. To date, the effectiveness of wearing padded gloves to reduce hand and finger injuries is not known.

These hand and finger injuries are important in that they may be underestimated in terms of severity and long-lasting sequelae. Fractures and tendon injuries of the hand resulting from any trauma (not

just sports injuries) can result in significant long-term and permanent disability and have been associated with permanent loss of motion and function, osteoarthritis, work sick leave, lost productivity and disability, reduced general health status, and high societal costs.^{18,19} Thus, it is important to understand the relatively high rates of hand and finger injuries in the sport of field hockey (and AFF), particularly in terms of preventability.

On the other hand, there is a much higher percentage of upper limb injuries (mainly finger and hand) in AFF, as compared to basketball. A previous epidemiological study on AFF found that fingers were the most injured bodypart (39%).²⁰ As the object of flag football is to grab the flag of the opponent, this technique leads to a greater chance of upper body injury, especially fingers and hand, compared to the technique of tackling the opponent, which leads to lower body injury. In the candidate's study, almost half of these finger injuries were associated with the fingers being caught in the opposing player's pocket (adjacent to the flag), hence the intervention involving the prohibition of pockets in his intervention study.

The question arises whether some form of padded gloves would reduce the non-pocket causes (60%) of hand/finger injuries in AFF. The problem with research to investigate this subject is that with the exception of hand warmers worn during inclement weather, gloves of any sort are prohibited by International flag football rules.¹⁶ Given the high rates of severe hand injuries in both field hockey and AFF, future consideration of mandating hand protection for all positions may be warranted.

Ankle injuries in basketball are far more prevalent than in the other two sports. When comparing AFF and field hockey to basketball, the ankle injury percentage distribution is approximately 1/3 less. This is explained by the fact that ankle injuries are far more common in the sports that involved both running and jumping, with the highest rates occurring in basketball.^{21, 22, 23} The fact that jumping in close proximity to

other players and changing direction while running are major components of basketball and volleyball, likely explains the findings that they had the highest ankle injury rates.²⁴

Player-position injury comparison with American tackle football

When trying to compare the incidence of player-position injuries between AFF and American tackle football (ATF), researchers must take into account the fact that there is some flexibility as to how some of the player-positions function, and especially how they are defined (Table 2.)

Sport Type	American Tackle Football (Karpakka J, 1993) ²⁵	American Flag Football (Kaplan et al,2012) ¹⁰
Offensive Line	45.5%	21%
Defensive Line	41%	37%
Quarter back	5.4%	15%
Wide receiver	8.1%	28%

Table 2. Player-position injury comparison between AFF vs. ATF

Five examples are presented:

1. In adult AFF, there are typically 3 wide receivers¹⁶ (the players who try to catch the ball, thereby advancing play) . In ATF, there will usually be 3-5 receivers on a play.²⁶
2. In ATF, the running back is the person who tries to advance the ball by running with it across the line of scrimmage - basically crashing through the defensive line. In AFF, it is the quarterback who runs, or at least it's a very different position (because there isn't supposed to be any "crashing through" the opponents).
3. The offensive line are the players who protect the quarterback (the person who tries to advance the ball by passing it to a teammate), or try to push people out of the way for the running back. Most offensive linemen are not allowed to catch a pass. In AFF, there are typically two offensive linemen, whose job it is too protect the quarterback (the person who tries to advance the ball by passing it to a teammate), or try to push people out of the way for the running back. In ATF, there are about 5-7 offensive linemen.²⁶
4. Cornerbacks and safeties are the defensive players who primarily try to prevent offensive players from catching a pass. The terminology is rather more ambiguous than the offense, since there are all sorts of defensive "coverage schemes", which make the differentiation between corners and safeties (and also Linebackers and Corners, see above) somewhat artificial, and there are different contingencies for dealing with pass plays and run plays, and for different offensive alignments. In AFF, there are generally 4 corners and safeties.¹⁶ In ATF, it depends a lot on how many receivers the offense has, but typically there will be 2 corners and 2 safeties.²⁶
5. In ATF, typically one offensive player out of eleven is the quarter back , and 3-5 of 11 are usually receivers.²⁶

As can be seen from the above, there are numerous differences regarding both player-positions as well as the percentage of players in each position between AFF and ATF. This has a direct impact on the percentage number of injuries per player-position between the different sports and thus makes comparison of player-position injuries challenging.

When analyzing the percentage differences in the offensive line between ATF and AFF, offensive players in ATF incurred far more injuries than defensive players. This may be explained by the fact that in AFF, there are typically only two offensive linemen, whereas in ATF, they represent 5-7 out of the 11 player positions. In ATF, running backs and linebackers (defensive line) had the greatest number of injuries. This is not surprising, because running backs, as primary ball handlers, are tackled frequently and these tackles are most often performed by linebackers.²⁷ As can be seen above (point 5.), the proportion of quarterbacks and receivers in ATF is far lower than in AFF. In AFF, the wide receiver's objective is to get past the defensive cornerback, in order to be open to receive a pass. The cornerback is allowed to push the wide receiver only within the first 4.5 metres past the line of scrimmage. This puts the wide receiver on the receiving end of physical contact, and thus at a high risk for injury. The quarter back is highly susceptible for injury as he is targeted by the defensive lineman position as quickly as possible, to prevent or to obstruct a pass.

Overuse injuries compared to other sports

Overuse injuries are inclusive of a broad spectrum of injuries within sports medicine. Repetitive stress on the musculoskeletal system without adequate and appropriate preparation and rest can result in chronic or overuse injuries in athletes of any age.²⁸ Classically, they are defined as chronic injuries related to “constant levels of physiologic stress without sufficient recover time.” Globally, they can

be perceived as the outcome of the difference between the volume of the stress or force applied to the body and the ability of the body to dissipate this stress or force.²⁹

Overuse injuries are generally a product of the application of an applied load to the body and the body's ultimate inability to dampen the applied load. This may be due to intrinsic factors which limit the body's ability to dampen the load or extrinsic factors which increase the load which is applied. Using this theory, programmes designed to prevent overuse injuries should target impairments which decrease the individual's ability to dampen forces applied to the body and encourage participation in appropriate progressions of training to increase the individual's ability to dampen the applied load.³⁰

The subject of overuse injuries is not expanded upon in any of the published papers relating to both the epidemiology and the prevention of injuries in AFF. This is because they are virtually non-existent in the amateur sport of flag football (Table 3) . In the epidemiological study (chapter 2), only 1 overuse injury (0.62% of the total reported injuries) was reported as a result of flag football. The other 2 previous epidemiological studies reported in the literature^{20,31} found similar results. This may be because at present flag football is an amateur sport, played mainly on a recreational basis. Players seemingly do not participate to such an extent that overuse injuries would play a significant factor in the realm of injuries in this sport. This may be compared to other sporting activities, where overuse injuries are more of a significant factor (Table 3.)

This AFF study used the standard time-loss injury recording method to record injuries. The standard time-loss injury recording methods have been found to rarely discover overuse-type injuries, hence the relatively new suggested methodology published by Clarsen B et al, 2012³², (which in their study identified more than 10 times as many cases than the standard method) allows for the use of a broad

injury definition and a means of quantifying injury severity that is not dependent on time loss. Using their new approach of monitoring athletes' health using regular online questionnaires, enables valid and reliable registration of all types of problems, including illness, overuse injury and acute injury. Using this new approach, it may have been possible that some overuse injuries were overlooked in the AFF study.

Sport	American Flag Football	Ice hockey	Field Hockey	Swimming	Football	Volleyball	Handball	Cycling
Percentage of overuse Injuries	1% (Total) ²⁰ 0.65% (Total) ¹⁰	1.4% (Total)	2.93% (Total)	55.7% (Shoulder)	65.7% (Lower Limb)	36% (Knee)	22% (Shoulder)	23% (Knee)
Reference	Collins RK, 1987 ²⁰ Kaplan et al, 2012 ¹⁰	Shroeder AN et al, 2014) ³³	Shroeder AN et al, 2014) ³³	Shroeder AN et al, 2014) ³³	Noya Sakes J et al, 2014) ³⁴	Clarsen B et al, 2014) ³⁵	Clarsen B et al, 2014) ³⁵	Clarsen B et al, 2014) ³⁵

Table 3. Overuse injury comparison between AFF vs. other sporting activities.

As can be seen by the diversity of injury percentages in Table 3., overuse injuries are typically very sport-specific. As more of the population participates in sporting activities and competition becomes more fierce, the prevalence of overuse injuries will increase. However the evidence which exists does support the potential for specific targeted prevention programmes to reduce injury risk. Assessment

of risk factors underlying mechanisms of overuse injuries indicate a potential link between acute injury prevention and overuse injury prevention.³⁰

In addition, preliminary attempts to use targeted neuromuscular training to reduce the incidence of overuse injury shows promise in small cohorts. Future research, including large, multi-center trials are needed to recruit and retain the large numbers of young athletes in longitudinal, prospective cohort studies in order to fully power these Level I and Level II experimental designs. This is warranted to investigate the potential for targeted neuromuscular training to reduce overuse injury rates or if other underlying risk factors need to be addressed before more significant reductions in overuse injury incidence rates are seen.

Contact vs. non contact injury prevention

Ninety per cent of the injuries reported in the AFF epidemiological study (Kaplan et al, 2012) were traumatic, contact- type injuries. The other 2 previous AFF epidemiological studies reported in the literature found very similar results.^{20,31} In Kaplan et al's study¹⁰, nearly 80% of the knee injuries and 50% of the ankle injuries were as a result of direct contact with the ground or with another player. Although numerous multicenter trials and systematic reviews have been published in recent years that investigated whether neuromuscular preventative programmes can reduce the incidence of non-contact knee and ankle injuries^{36,37,38,39}, neuromuscular preventative programmes have yet to be investigated in reducing injury risk in contact-type sports.

Seasonal injury rates

Table 4. below plots the number of injuries vs. the months over the 2–season epidemiological and 2-season intervention trial.

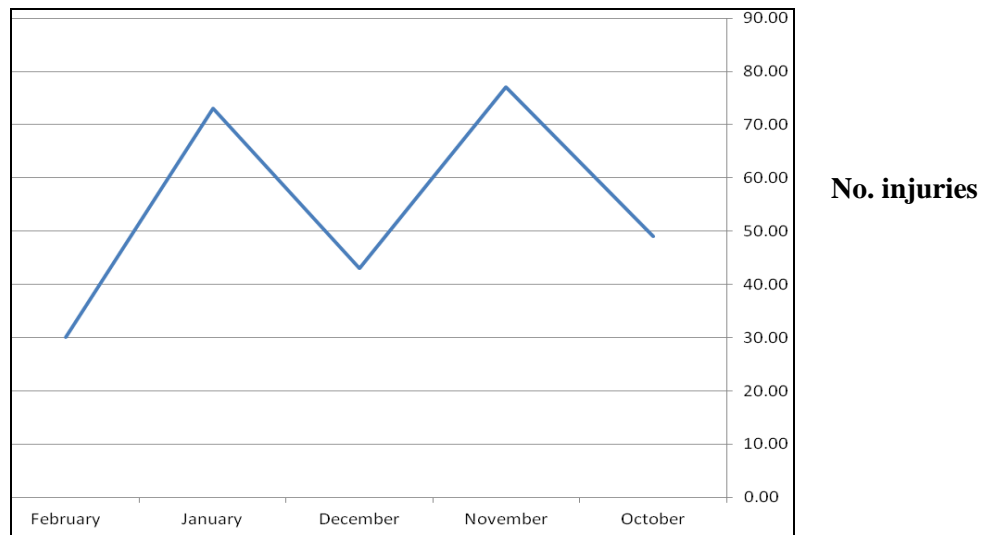


Table 4. Seasonal injury rates

The first peak 2-3 weeks into the season may be explained by the fact that at this stage, all the registered teams are playing each other, with the maximum no. of teams and players participating, therefore the most number of players are at risk to get injured.

The mid-January peak may be explained by the fact that this is the start of the play-offs and the competition between the teams is fierce to see who makes it into the final rounds. The peak drops rapidly as fewer and fewer teams make it into the final round of the play-offs.

Contrary to the above results in the author's study, in theory, it would make sense that injuries would be more likely be expected only at the end of the season when athletes often start to fatigue after months of training and competition. Proposed explanations of this variation in number of injuries across seasons vary across a broad spectrum of potential extrinsic risk factors, including weather and

playing surface^{40,41,42}, venue being indoor or outdoor⁴³, and time of season.⁴⁴ There is also the question whether the rate of traumatic, contact-type injuries vs. non-contact, intrinsic injuries differ in the beginning or at the end of the season. This has yet to be investigated.

Study limitations

Contact vs. non-contact flag football

Flag football has mutated into many variations and may simply be divided into "contact" or "non-contact". In non-contact flag football, there is no blocking. In some leagues, defensive players may not get in the way of a runner. Offensive players are not allowed to hand block defensive players to prevent them from grabbing the flag. The epidemiology of injuries in these variations of play will therefore seemingly be different. As the current authors' study involved contact flag football, where blocking was permitted (Chapter 2), the results will not be representative of those leagues.

Randomisation

Whilst randomized controlled trials are theoretically ideal, they are hard to conduct—particularly taking into account the broad safety culture of a sport and the safety behaviours of its participants.^{7,45} Pasanen et al, 2008⁹ did however show in a cluster randomized trial comprising female footballers, that randomization in sports injury prevention is possible, with good intervention results. Ecological study designs (where the unit of analysis is a population rather than an individual⁴⁶) are promising for assessing the value of interventions⁴⁷ and are becoming more common in the sports injury research context. However, they do require the use of appropriate statistical methodology that takes into account potential clustering effects and other dependencies in the data.⁴⁸

Randomization would have raised the level of evidence of this study from level II to level I.³⁸ This was not possible for numerous reasons. As a result of the current evidence that both ankle braces and mouth guards may reduce the incidence and severity of ankle and oral injuries respectively, the ethics committee who approved this study, did not approve of randomizing the study cohort. As the AFI is an amateur league with no organised team coaches to monitor the interventions used, there existed the risk of an unplanned crossover effect, whereby players assigned by the randomization to the control group could have had second thoughts and decided of their own accord, to utilize the intervention measures provided. This phenomenon would have posed a serious challenge in the analysis of the data and undermined the very experimental design.⁴⁹

Future studies

Further well-designed randomised studies are needed on preventive actions and devices that are in common use, such as preseason medical screenings, warming up, proprioceptive training, stretching, muscle strengthening, taping, protective equipment, rehabilitation programmes and education interventions (such as increasing general injury awareness among a team).⁵⁰ More pertinent to flag football, is the need for high quality intervention studies, in order to determine whether the influence of soft headgear as well as changing the blocking rules, will be instrumental in further reducing the injury incidence and severity in this fast growing international popular sporting activity, thus making contact flag football safer for all involved.

Conclusions

This is the first prospective prevention study in American contact flag football and has provided convincing evidence that finger/thumb injuries can be significantly reduced in flag football. Based on the results obtained, recommendations to the IFAF include the mandatory use of mouth guards, and the strict implementation of the no-pocket rule, including harsh penalties for their violation. In addition, comfortable-fitting ankle braces, the use of soft headgear and changing the blocking rules, should be considered. To evaluate the study's effectiveness and to see whether player behaviour has indeed changed, the candidate convinced the AFI management to agree to manage a follow-up study over the next 2 seasons (2014-16), where mouth guards and the no-pocket rule would be mandatory. The results of this future study would prove whether the injury incidence reduction could be maintained, not within the context of a strictly-controlled intervention study (i.e efficacy), but rather under the control of the league itself. It will further evaluate whether the interventions, new rules and penalties will remain a permanent feature of the game of flag football.

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CHAPTER 6

Recommendations to the International Federation of Flag Football

As was mentioned in the introduction section, one of the intended aims of this study was to ensure that the successful implementation methods in this study would not only become a permanent aspect in flag football on a local and national level, but that an earnest attempt would be made to convince the International Federation of Flag Football to in fact change the rules at an international level as well. To this extent, information was sent to the IFAF decision making body, detailing what prevention measures were instituted, what the results revealed, and what the recommendations were.

The following, were the issues raised and conveyed in the letter:

1. Following the introduction of the no-pocket rule, there was a highly statistically significant reduction in the number of hand/wrist injuries in particular, that resulted from the fingers/thumb having been caught in the opposing player's pockets, ($p < 0.05$).
2. Despite the above, 62% of the finger and wrist injuries were as a result of players colliding into one another during blocking or direct collision.
3. There was a 40% reduction in ankle injuries, just short of being considered significant ($p = 0.058$). No player who received and played with an ankle guard re-injured his ankle.
4. Although there was no reduction in the number of injuries in the head/ face region there was a significant difference between the cohorts with regards to the **injury severity** ($P < 0.05$).
5. For the first time in the 25 years of the AFI league's history, the use of mouth guards and the no-pocket rule become obligatory league rules and were strictly enforced. In the final season of this study (2012-2013), teams were penalized if any player was found playing with pockets or without a mouth guard. The inclusion of penalties may indeed explain the significant increase in compliance percentage, compared to the previous season. The authors view these league rule changes as a significant contribution in the prevention of sport injuries in flag football.

The authors examined the updated IFAF rules (2013), and noted the following:

- a) No pockets, press studs or clips are allowed (SECTION 3. Article 1.)
- b) Mouthpieces are only recommended for national competition games (R1-3-1)
- c) Headwear could be legal, if it does not endanger or offend other players (R 1-3-2)
- d) However, further on in the rules, there seems to be an apparent contradiction regarding headwear and mouthpieces:

ARTICLE 1. Mandatory Equipment

- d. All players must wear an intra-oral mouthpiece with a visible color

ARTICLE 2. Illegal Equipment

- b. Any kind of headwear or helmets (caps, hoods, bandanas, headbands or similar) is forbidden

8. It should be noted in the list of penalties section (Summary of Penalties, pg 23), that there are no penalties for a violation of any of the above rules.

In summary, our recommendations, based on convincing scientific investigatory evidence, were as follows:

- 1.** Blocking rules (in contact flag football) should be changed, such that the hands cannot be used to grab, block or pull the opponent. Clearly stated penalties in the rules should appear for its violation.
- 2.** Mouth guards of a visible color and with no part sticking out more than 0,5 inch (1,25 cm) should be mandatory, including clearly stated penalties in the rules for its violation.
- 3.** There must be strict implementation of the no-pocket rule, including penalties for its violation.
- 4.** Comfortable-fitting ankle braces should be strongly recommended.
- 5.** The use of soft headgear should be strongly recommended. A future intervention study is needed to study the influence of soft headgear in preventing both the incidence and severity of head and facial injuries.

CHAPTER 7

Presentations at International conferences

"Nothing will ever be attempted if all possible objections must be first overcome"

- Samuel Johnson

1. **"Epidemiology of injuries in flag football"**: Poster presentation.

IOC World Conference on Prevention of Injury & Illness in Sport”, Tromso, Norway, 2011

2. **"The Prevention of Injuries in American Flag Football": Results of a pilot study**. Oral presentation. 9th Biennial ISAKOS Congress , Toronto, Canada, 2013.

3. **"Can we prevent injuries in contact flag football?"** Oral presentation. 2013 Asics Conference of Science and Medicine in Sport, Thailand

4. **“Injuries can be prevented in contact flag football!”** Poster presentation.

IOC World Conference on Prevention of Injury & Illness in Sport”, Monte Carlo, 2014

5. **"Injury Prevention Programmes - YES, they do work!"** Workshop presentation
IOC World Conference on Prevention of Injury & Illness in Sport”, Monte-Carlo, 2014

CHAPTER 8

Nederlandstalige samenvatting

Sport wordt beschouwd als een essentieel onderdeel van een actieve en gezonde levensstijl, waardoor het risico tot het oplopen van verschillende ziekten vermindert en bijdraagt tot een beter psychisch en fysisch welbevinden. De gunstige effecten van sporten moeten afgewogen worden tegen het risico op letsels, die deels onvermijdelijk zijn. Hoewel de noodzaak aan interventie studies in de 'realworld' context van sportbeoefening duidelijk aanwezig is, is er tot op heden heel weinig onderzoek gedaan op dit belangrijke onderzoeksdomein.

Het oorspronkelijke onderzoek binnen dit doctoraat is begonnen in de loop van het contact "flag football" seizoen in Israel, in 2005. Hoewel contact flag football een niet-contact sport is, en de daardoor opgelopen blessures beschouwd kunnen worden als "licht", zijn de kosten van behandeling van deze blessures hoog. Dit onderzoek toonde aan dat 88% van de blessures opgelopen werden in 5 anatomische gebieden: handen, gezicht/hoofd, knieën, enkels en schouders. Bijna 40% van alle hand/vingerverwondingen (die bestaan uit 30% van alle blessures) waren een direct gevolg van vingers die ingeklemd bleven in de broekzakken van de tegenstanders.

Als resultaat van de epidemiologische gegevens welke geëxtrapoleerd zijn uit deze studie, is een blessure preventieve pilot studie opgezet over een seizoen (experimentele cohort) met als doel een aanzienlijke vermindering te verkrijgen van de incidentie en de ernst van sport gerelateerde letsels. Vier interventies werden uitgevoerd: verbod van in de broekzakken te graaien (no pocket-rule), het dragen van enkel braces, en het verschaffen van een informatiebrochure over blessure behandeling. In deze studie werd een daling van het aantal letsels vastgesteld in alle lichaamsdelen, maar statistische significantie werd alleen geconstateerd in het aantal vinger/duim letsels ($p < 0,05$)

Op basis van de ervaringen van de pilot studie werd een 2-seizoens prospectieve blessure-preventieve cohort studie (hoofdstuk 4) opgezet.

Deze studie toonde een vermindering van 88% van het totale aantal blessures aan. Een statistisch significante vermindering van hand/pols verwondingen werd vastgesteld ($P < 0,001$). Ook was er een significante vermindering van de ernst van milde tot matige verwondingen ($p < 0,05$). De "no pocket-rule" en het verplichte gebruik van mondbeschermers is op basis van de studieresultaten uitgegroeid tot een definitieve regel in de AFI-competitie.

Met behulp van de verkregen resultaten zullen aanbevelingen worden gedaan aan de International Federation of Flag Football (IFAF).

Aanbevelingen zijn gedaan aan de IFAF (hoofdstuk 6) waaronder het wijzigen van de regels met betrekking op blokkeren (in contact flag football), mondbeschermers verplicht te voorzien van duidelijke kleur, en de strikte toepassing van de 'no pocket-rule'. Sterk aanbevolen werd het dragen van comfortabel zittende beschermende enkelbraces en zachte hoofddeksels. Ook het veranderen van de regels met betrekking tot blokkeren, zullen leiden tot een verdere reductie van frequentie en ernst van blessures in deze snel groeiende internationale sport, waardoor contact flag football veiliger voor alle betrokkenen wordt.



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