An epidemiological study of injuries during 'Police Mutal Aid Standard' training in the Greater Manchester Police

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in the Greater Manchester Police Force.

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ABSTRACT

Background

Greater Manchester Police (GMP) has 6,794 officers most of which receive Police Mutual Aid Standard (PMAS) training.

Aim

To collect data on PMAS training injuries, describe the occurrence of injuries and identify possible risk factors.

Method

Chi square analysis was used to test 4 hypotheses. Exposure time was taken into account.

Hypotheses 1:	The injury rate during PMAS training in GMP is different to other forces.
Hypotheses 2:	Some components of training have a higher incidence of injury than others.
Hypotheses 3:	Some mechanisms cause more injuries than others.
Hypotheses 4:	Some parts of the body are more frequently injured Than others.

Results

During the period 1 April 1999 and 31 December 2001, 10,609 officers were trained and 300 injuries were recorded. There were 0.0118 injuries per day. The difference between injury rates in GMP and other forces was not significant ($p = 0.108$). There was a highly significant difference in the incidence of injury during different components of training ($p < 0.0005$). The 'Violent Deranged Person' scenario was the component causing most injuries . The 'Warm Up' had a high incidence of injury considering its nature and purpose. The difference in incidence of injury caused by different mechanisms was highly significant ($p < 0.0005$). Being struck by missiles was the mechanism causing most injuries. There was a highly significant difference in the number of injuries to different parts of the body ($p < 0.0005$). The leg and ankle received most injuries.

Conclusions

The evidence from this study can be used to guide future injury prevention strategies for PMAS training.

This work is original and has not been previously submitted in support of a Degree, qualification or other course.

Signed .

Date ....

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INTRODUCTION

Background

Greater Manchester Police (GMP) is the second largest police force in Britain. GMP is responsible for the county of Greater Manchester; it coves 495 square miles and has a multicultural population of over 2.5 million people. The city of Manchester is the geographical centre of the force, it is surrounded by a further 9 metropolitan areas that make up GMP, Bolton, Bury, Oldham, Rochdale, Tameside, Salford, Stockport and Wigan. The force strength at 31 March 2001 was 6,794 full time officers (Her Majesty's Inspector of Constabulary (HMIC, 2001). The force has responsibility for the health and safety of its officers under Section 2, Health and Safety At Work Act (HASAWA) 1974, GMP Health and Safety Department (2001). One of the ways a force fulfils its obligations is through ensuring officers have the necessary equipment and training to deal safely with the different tasks they perform. One of the most violent, dangerous situations officers may encounter are public order incidents. Examples are:

1. Regular clashes between rival football fans. There are 3 Premier League clubs and 5 football league clubs in the GMP area.

2. Incidents of alcohol related disorder in city and town centres. The number of licensed premises in Manchester city centre alone increased by 240% between 1997 and 1999. The city centre regularly attracts150,000 people for night time entertainment (HMIC, 2001).

3. Less frequent but larger scale disorder, such as the recent riots in Oldham, Manchester.

It is necessary that officers receive training that enables them to deal effectively with such instances while ensuring as far as possible the officer's safety. As a result, operational officers in GMP are required to attend public order training each year. This is a 2 day course during which a range of tactics, likely to be employed, are practiced. Some officers in specialist departments receive extra training in use of specialist equipment (MOE training). The training currently takes place at a purpose built training venue, the Clayton Brook training complex in Openshawe, Manchester. The complex consists of large concrete blocks to simulate buildings, streets, purpose built houses for house entries, stairways, sports stadium seating, prison area and a purpose built violent deranged person scenario room. The unit is staffed by a Chief Inspector, and Inspector, 2 Sergeants and 9 Trainers, who are all National Police Training accredited (GMP Public Order Department 2002). A dilemma for the police is how public order training can be made realistic, without creating a risk to the participants. It appears logical that as the training becomes more realistic, for example, more bricks being thrown and officers playing the role of rioters becoming more aggressive, it is likely that injuries will increase. Weaver, Moore and Howe (1996) state that sport cannot be pursued without risk. The same can be said about public order training which carries an inherent risk of injury. It seems prudent however, that the GMP make efforts to reduce injuries without losing the reality of the training.

Risk assessments are currently carried out on all techniques/tactics carried out during public order training. The risk assessments are carried out by the public order trainers. The trainers use their own experience and common sense to identify hazards and introduce control measures. This identification of risk is not based on any epidemiological evidence. Although experience of the professionals is useful and should be highly regarded, epidemiology can assist in providing better risk assessments as Wallace (1988) states, "While sports injury prevention policy will always rest on considerations additional to data collection, sounder judgements will usually be possible when accurate data bearing on the issue are present." It has been said that epidemiology and prevention are inextricably linked, the former being meaningless without the latter and the latter approaching impossibility without the consideration of the former (Weaver et al, 1996).

Aims and Objectives

The aims of this study are to collect data on public order training injuries and to describe the occurrence of injuries and identify possible risk factors. This data could then be used to assist the Public Order Training Department with future risk assessments and the development of strategies to reduce injury. This study will only examine injuries during Police Mutual Aid Standard training (PMAS). Injuries occurring during other activities, carried out at the Public order training complex, will not be included.

Five specific objectives have been set for the research:

1. The extent of the injury problem will be described; The number of injuries between 1st April 1999 and 31st December 2001 will be shown and compared to figures for injuries from PMAS training in other police forces.

2. The components of public order training (i.e. what tactic or activity students were involved in) that are most likely to result in injury will be identified.
3. The mechanisms responsible for causing injury will be identified.
4. The parts of the body that are most commonly injured will be identified.
5. Recommendations will be made to reduce the risk of injuries based on the study findings.

LITERATURE REVIEW

There have been many epidemiological studies of sports injuries but to the author's knowledge, this is the first detailed epidemiological based study into injuries during police public order training. However, studies on sports injuries are relevant to this dissertation as public order training is a physical activity similar in all practical respects to a sport and the issues raised in the literature on sports injuries are relevant to this study. Studies of sports injuries will be reviewed here and the relevance to public order training of the issues raised will be discussed. One of the major issues discussed in the literature on sports injuries is the actual definition of an injury. Varying definitions of what constitutes an injury are found in the literature, this makes comparisons across studies problematic. Wallace and Clark (1988) state that it is crucial to have precise injury definitions. Wallace and Clark outline various criteria that have been used in the past to define injury. These criteria include the presence of a new symptom or complaint, decreased function, decreased athletic performance, cessation of practice and consultation with medical personnel. Many other researchers such as Stone (1996) and Van Mechelen, Hlobil and Kemper (1992) have reported the need for standardised definitions of injury when comparing studies. Van Mechelen et al list studies where differing definitions of an injury have included an injury for which an insurance claim has been made or an injury that has been treated at a hospital department. Van Mechelen et al argue that such differing definitions of injury will account for differing incidence rates reported in studies making comparisons between them worthless.

Junge and Dvorak (2000) report that differing definitions of injury used in studies of football injuries make comparisons between studies almost impossible. Junge and

Dvorak highlight an example being the definition used in recent studies that an injury is any injury that forces a player to miss the next training session or game. This definition can be effected by the frequency of training or games. A player who only trains once a week for instance, many have a better chance of recovering before the next training session than a player who trains every day. Also some players may train with an injury while others may not. An additional problem with this definition of injury is that injùries may be sports specific, for instance a gymnast may not be able to train with a sprained wrist whereas a footballer may (Caine, Caine and Lindner 1996). This makes for further problems when comparing between sports.

The injury reporting system used can have an influence on the definition of injury and the type of injuries recorded (Meeuwise and Love 1997). In a review of injury reporting systems Meeuwise and Love report that these two issues together cause bias when comparing injury rates across studies. For example, systems that use hospital records to record the number of injuries in a study would likely have a higher proportion of serious injuries but an under reporting of less severe injuries compared to a study where all injuries are recorded after the physical activity by a trainer or medical personnel. In their review of reporting systems Meeuwise and Love conclude that it is unlikely that one universal system will fit all study situations. They suggest that if the system used to collect injury data is described in the study, some comparison across studies may be possible by taking design differences into consideration.

The GMP definition of injury and the reporting system used will now be described, so that the reader can interpret the system of data collection when comparing across studies. The definition of GMP public order training injury is any injury declared as such to the trainer at the end of or during public order training (GMP Public Order Department 2002). Police forces keep a record of all injuries that occur at work. Forces are obliged to record certain types of injury under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995 (Stranks 1999). All injuries need to be recorded as there are elements of the general health and safety duty in section 2 of the Health and Safety at Work Act (HASAWA) 1974 that an employer would be unable to comply with if a properly developed accident reporting and recording system was not in place (Akass 1995).

The injuries in GMP are recorded on a Form 700B (Appendix A). GMP orders all its officers to complete the 700B when injured. Officers also have a vested interest in completing the 700B as their pay and pensions can be adversely affected if they are injured on duty and have not filled it in. This vested interest and pressure from supervisors ensures that the 700B is an accurate record of injuries. In addition, public order trainers ask students at the end of a session if they have been injured and all injuries declared are recorded prior to students leaving the venue. As standardised forms are used across forces, comparisons between injuries within GMP and across other forces can be compared while avoiding the pitfalls previously discussed.

To describe the severity of injuries, the number of days an officer has been sick as a result of public order training injuries, will be outlined. GMP use the following system to record the severity of injuries. The 700B contains the question, "Did the officer report sick?" Yes or No. In addition, when an officer reports sick, they fill in a sickness form and if the sickness resulted from an injury on duty, the details will be recorded. These details, on how long officers have been sick as a result of public order training, are maintained by the Force Sickness Clerk and can be used as an indication of the severity of injuries. The nature of the injury is recorded on the 700B by a trainer in the public order department. The method used is a blank box in which the trainer puts a description of the injury after speaking to the injured person. This type of system has been criticised by Lindenfield, Noyes and Marshall (1988). Firstly the trainer may not be sufficiently qualified to diagnose the type of injury correctly or with enough specific detail. Lindenfield et al suggest that injuries should be recorded by trained medical personnel who can record an injury in correct diagnostic terms. Lindenfield et al also suggest that just filling in a blank can result in similar injuries not being documented in the same way, adversely affecting the injury record data and that predetermined categories should form part of the injury recording form. These predetermined injury categories would assure standardised reporting. Lindenfield et al suggest that a blank is acceptable if used with predetermined categories, but not on its own. Although the suggestions by Lindenfield et al are valid, in that it is possible various terms may be used to describe injuries, such as strain, sprain, muscle pull, the relevance of this depends on how the researcher wishes to use the data. In this dissertation the information recorded on the 700B has been sufficient to achieve the objectives set. Some of the detail suggested by Lindenfield et al, for example dividing knee injuries into categories, such as anterior cruciate ligament strain and posterial cruciate ligament strain, is too specific and unnecessary to achieve the aims of this dissertation. Such specific definitions as those outlined above would indeed require the skills of a medical practitioner.

In their review of athletic reporting systems, Meeuwise and Love (1997) report that all injury reporting systems have their strengths and limitations. For example, the simplicity of a reporting system may be a strength in one respect, as it may be more convenient for recorders of injury, but a weakness in that it doesn't collect data that is as specific as a more complex form. In an attempt to design a system of recording that overcomes all issues regarding the comparitability of studies, Lindenfield et al (1988) do not recognise in their study that the need for specific definitions and other issues depend on what the researcher wishes to achieve and may vary widely.

Another major issue in epidemiological studies is how incidence of injuries is expressed. In epidemiological studies, the most fundamental unit of measurement is the rate. This basically consists of a denominator comprising the number of persons at risk of that occurrence (population of risk) and a numerator comprising the number of persons or events of interest chosen from that denominator (Wallace 1988). As an example, rates of ankle injury could be expressed as:

$$\frac{\text{Number of Ankle Injuries}}{\text{Total Number of Participants}}$$

The time period could be per week or per season. The arithmetic rate is simple but can be deceptive as it doesn't take into account the degree of exposure. Exposure has been defined as the number of hours during which the person actually runs the risk of being injured (Van Mechelen, Hlobil and Kemper 1992). Van Mechelen et al use the term incidence instead of injury rate and they suggest that incidence should preferably take into account exposure time. They suggest that this would make comparisons between activities or sports more valid. Wallace (1988) and Kennedy, Vanderfield and Kennedy (1977) also suggest that taking into account exposure time increases validity.

The following study of football injuries by Hawkins, Hulse and Hodson (2001) demonstrates how exposure can effect the conclusions in a study. Hawkins et al studied football injuries in the English leagues over a two year period. All players who were injured completed questionnaires on their injury. The aims of the study were clearly defined. The aim was to establish the underlying causes of injury within football to help guide future preventative methods. Hawkins et al do not attempt to make comparisons between the findings in their study and other studies. The study identifies the mechanisms and occasions when injuries most often occurred. Hawkins et al did not take exposure into account at all. For example, it was identified that August and September are the months when most injuries occurred. April was identified as the month when the least number of injuries occurred. It could be that less training or games took place in April than other months, therefore less injuries would be expected during this month. When exposure time is taken into account the fact that more injuries occurred in September may have less practical significance. Another example is the report that 35% of injuries occurred during training and 65% during competitive matches. A logical conclusion from this could be that future injury prevention strategies should concentrate on competitive games as this is where most injuries occur. A comparison between training and competition, taking exposure into account may produce different results, leading to a different conclusion.

Another issue related to exposure is how participation is defined. Lindenfield et al (1988) propose that exposure time should be sharpened to include actual time exposed to risk, rather than overall time spent on sports participation. Junge and Dvorak (2000) report on how exposure rates in soccer injury studies have been misleading. They report that some studies have estimated exposure by multiplying the number of players by the hours of participation per week and the weeks per season. Other studies have documented the individual amount of training and game playing time for each player. The first method does not take into account the times players are absent from training sessions or games. The first method, therefore, overestimates exposure time and cannot be fairly compared to the second method. A review of the following studies further illustrates some of the issues regarding injury rates/incidence, exposure, participation and the definition of injury.

Chambers (1979) carried out a study of orthopaedic injuries in athletes, ages 6 to 17. The study was done over one year, in the controlled environment of a military post. Data was collected on participation in six supervised sports, football (American), soccer, basketball, baseball, swimming and gymnastics. Chambers used the following formula to express incidence, taking into account exposure:

Formula

$$\text{Injury Index Factor} = \frac{\text{Number of Injuries} \times 10^4}{(\text{No. of Participants}) \times (\text{Average Hours of Participation}) \times (\text{No. of Weeks in Season of Sport})}$$

Chambers (1979) found that when the injury index factors were compared, the risk a participant has for sustaining injury in football was twice as high (1.72) as its nearest competitors, basketball (0.88) and gymnastics (0.88). Soccer had an index factor of 0.29, baseball 0.14, and swimming had a factor of zero. Eighty percent of all sports related orthopaedic injuries involved the upper extremity. Lower extremity orthopaedic injuries occurred only in football and gymnastics. The Chambers study is useful in comparing injuries across the various sports, in the population studied. There are however, difficulties in comparing this study to other studies. Firstly, the strict definition of injury to include orthopaedic injuries is unusual as it doesn't take into account soft tissue injuries, such as strains and sprains which can be serious injuries. This can result in under-reporting of the incidence of injury compared to other studies and a misleading picture of which sports carry a high risk of injury. Most other studies include soft tissue injuries in their definition of injury, even studies that tend to under estimate less severe injuries such as those which use hospital records to document injuries (Meeuwise and Love 1997). Chamber's conclusion that persons concerned with reducing injuries in to the growing athlete should concentrate on reducing risk of injury to upper extremities is not valid as he has not taken soft tissue injuries into account. A review of the literature on soccer injuries by Larson, Pearl, Jaffet and Rudawsky (1996) found that the most common injuries in soccer were sprains, strains and contusions. Larson et al report that the majority of soccer injuries occur in the lower extremities, prospective studies (75.4-93%) and retrospective studies (64-86.8%). This review is in stark contrast to Chamber's study which reported no lower extremity injuries in soccer during his study. This highlights how the definition of injury, can have a substantial effect on the results and conclusions of a study. As Chamber's in his study clearly outlines his definition of an injury and the system used to collect the data, the researcher reading his study is able to put the study in to the correct context and make a critical assessment of the study's conclusions.

Secondly, the formula Chamber's uses to calculate the injury index factor (described earlier), basically expresses injuries per 10,000 hours of exposure. It is more usual in epidemiological studies of sports injuries for injuries to be expressed per 1000 hours of exposure (Travisano 2002). As Chambers adequately describes his formula, again the reader is able to interpret the data accordingly.

Thirdly, another issue highlighted in Chamber's study is how participation was estimated. Chambers states that all activities were recorded by a "single recreational services office (RSO) assuring accurate data recording of number or participants, as well as frequency and duration of practice periods." Chambers does not specify however, how the "average hours of participation" (AHP) is calculated. The AHP could have been calculated by asking participants at the end of a period of time, how many hours they had participated in each sport. These recollections could be subject to recall bias or over estimation on the part of subjects (Junge and Dvorak 2000). It could be that the AHP was estimated by the RSO looking at the scheduled events and number of participants and working out the mean number of hours participation. This would not take account of participants dropping out and not taking part in all or some of the event. This would result in an over estimation of AHP. The most accurate way to establish participation would be for a researcher to watch each event and time exactly how long each participant was active.

The final problem with Chamber's study, is the way the cohort has been selected. It may be that 6-17 year olds on a military base are not representative of other 6-17 year olds. Also the way sports are played and supervised on a military base may be different to the way they are in a civilian environment. These possible biases mean it may be invalid to apply the results of this study to 6-17 year olds in the general population.

De Loes and Goldi (1988) conducted a study of acute injuries from sports and physical exercise over a one year period in a Swedish rural municipality. The author's present injury data on 17 sports. They found that the majority of the injuries were from soccer: 50% of the males and 27% of the females. The issue of injury definition is again relevant in this study. De Loes and Goldi have included only acute injuries in their study. The data has come from records of people attending medical centres for treatment. Therefore, people who have been injured and have not attended a medical centre have not been included. The severity of the injuries in the population may therefore be over estimated and the total number of injuries underestimated (Meeuwise and Love 1997). De Loes and Goldi however, clearly define their definition of an injury and the system used to record the data thereby enabling the reader to interpret the data and make informed conclusions.

De Loes and Goldi have taken exposure time into account when working out the denominator for the incidence rate. They express the incidence per 1000 hours of activity. Data on participation were collected from 3 separate sources:

Source 1

A questionnaire was sent to a random sample of 7% of the population between 15 and 59 years. It concerns participation in sports during leisure time and enquires about frequency, intensity, duration, and type of activity. Non response was 20.9%.

Source 2

Data on team and combat sports came from sports clubs in the region. They reported the number of teams, participants, the amount of practice and the number and duration of matches or competitions.

Source 3

The number of pupils and the amount of lessons in physical education in schools in the municipality were obtained from the Swedish National Board of Education. This allowed the exposure to obligatory sport at school to be calculated.

The following issues arise from the data collection methods described. The non response rate in Source 1 was 20.9%. The question is "Are those who didn't reply systematically, different to those who did?" It could be that those who didn't take part in any activity decided not to reply. The non response rate for Source 2 is not included in this study. The self reports of physical activity used in Source 1 can be biased by issues such as recall bias and over estimation of the hours of sports participation which is common in such questionnaires (Klesges, Ech, Mellon, Fulliton and Somes 1990). The authors have estimated individual exposure. They have calculated exposure by multiplying the number of participants by the number of games or practices, as determined by Sources 1,2 and 3. There are two difficulties with this approach. Firstly, there is no way of ascertaining if a given person has been participating on a regular basis. As Meeuwise and Love (1997) state, it is assumed in this type of methodology that if they are a member of a team or relevant group, they are exposed (i.e. fully participating). However, it could be that the member of the group was not participating regularly, missing games or practices. Secondly, a person may not participate in a full game or activity. The design of the study is such that more accurate direct measurement of exposure is not practical. It is not mentioned in the study by De Loes and Goldi how the particular municipality used was chosen. It is therefore not known if selection bias is relevant and whether the results from this study are generalisable.

Requa, De Avilla and Garrick (1993) carried out a study of injuries in recreational adult fitness activities. Recognising the problem with comparing across studies, the stated intention of Requa et al was to compare a large number of activities in one study. This allowed the activities to be compared avoiding the biases caused by different study populations and different definitions of injury and exposure. Nine hundred and eighty six volunteers from fitness clubs and studios were recruited and followed over a three month period. Exposure was taken into account with incidence per 1000 hours of activity being reported. Twenty nine activities were compared in the study. Requa et al report that rugby and lacrosse stood out as their rates were three to four times higher than the combined team sports rates. A main fault in the study is that no mention is made of the statistical technique used to analyse the data. Also, there appears to have been multiple tests carried out on the data without consideration of the inflated risk of a type I error. Another problem with the study is that the method for selection of the participants was not described. Selection bias could be an issue invalidating the generalisations to a wider population that are included in the conclusion section. As the participants were only followed for three months, it may be possible that some seasonal bias was involved and the figures may have been different if the subjects were followed for 12 months. The issue of seasonal bias is highlighted in a study of injuries in runners by Lysholm and Wiklander (1987). They studied running clubs over a 12 month period. Exposure was taken into account and injuries reported per 1000 hrs of running. Lysholm and Wiklander reported 55 injuries in 39 athletes. They reported significant differences in the injury rate in different periods of the 12 month study. The highest rates reportedly occurring in the spring and summer. Again, the authors of this study did not specify which statistical tests were used to identify these. Similar findings of seasonal variations in the number of injuries have also been reported in soccer players, by Ekstrand and Gillquist (1983).

Summary

Differing terminology and definitions and different systems of data collection all have a bearing on the data collected in epidemiological studies. This makes comparisons across even well designed studies, problematic (Requa et al 1993). However, the following measures have been included in this dissertation and should make it easier for the reader to interpret data and draw conclusions:

1. The definition of what constitutes an injury has been stated.
2. The system used to collect injury data has been described.
3. The formula for calculating incidence and exposure will be defined.
4. In relation to exposure, how participation has been calculated has been explained.
5. A detailed account of any statistical techniques used, has been given.

METHODS

Data Collection

It has been decided that this dissertation will examine injuries occurring during PMAS training between the 1 April 1999 and 31 December 2001. Originally records of injuries dating back to 1997 were obtained. The tactics used during PMAS training changed in April 1999 and the tactics currently being taught were introduced on that date. It has been decided that limiting this dissertation to injuries occurring between 1 April 1999 and 31 December 2001 will ensure that comparison between categories is standardised and more relevant to current practice. Also on 1 April 1999 GMP introduced the registrar computer system for recording the number of officers attending training sessions. It is believed that records obtained from this date will be more accurate that those prior to this date. Retrospective records of injuries from two sources will be used:

Source 1

Computerised records of injuries obtained from GMP Health and Safety Department.

Source 2

Paper records of injuries obtained from the Public Order Training Department.

The records from Source 1 are complete and are obtained from the 700B as described earlier. The records from Source 2 are incomplete. The paper records however, contain a narrative which the computer records don't. This narrative provides very useful additional information. The keeping of paper records varies between divisions and departments in GMP. Paper records of injuries from the 700B are not normally reasonably accessible. The Public Order Department are rare in that they have attempted to keep and systematically file the paper record of injuries occurring during their training sessions

There is no apparent reason why the paper records kept should be systematically different to those that aren't. The most logical explanation is human error. Trainers may occasionally forget, due to pressures of work, to copy the paper record and file it in the Public Order Department's filing system.

Design

This dissertation is a retrospective study of injuries during PMAS training. A model termed the Sequence of Prevention (Van Mechelen, Hlobil and Kemper, 1992) was used to structure the dissertation. The model is shown in Figure 1:

Figure 1 Sequence of Prevention

Step 1 Establishing the extent of the injury problem.	→	**Step 2** Establishing aetiology and mechanism of injuries.
↑		↓
Step 4 Assessing the effectiveness by repeating Step 1.	←	**Step 3** Introducing preventative measures.

In the dissertation, steps 1 and 2 of the sequence were covered and suggestions were made for step 3. Step 4 is not in the remit of this dissertation.

Procedures

As in the first step of the sequence of prevention (Van Mechelen et al 1992) the data was examined to establish the extent of the injury problem. The number of injuries occurring during the following periods has been identified: 1 April 1999 - 31 December 1999; 1 January 2000 - 31 December 2000; 1 January 2001 - 31 December 2001.

The number of officers attending training during these periods was identified. Rates of injury per number of officers trained were calculated. Incidence of injury over the period 1 April 1999 – 31 December 2001 was calculated. Incidence took into account exposure using a formula adapted from Chambers (1979). The adapted formula calculated incidence per 1000 hrs of exposure as recommended by Travisano (2002).

$$\text{Adapted Formula} = \frac{\text{Number of injuries during period x } 10^3}{\text{Number of participants x hours active}}$$

Hours active means the amount of time in hours that officers were physically active during training. In order to calculate "hours active" for each person, detailed observations of PMAS training were made and accurate timings were taken. Officers attend training for 2 consecutive days each year. The training follows a set format so that all officers receive the same training (GMP Public Order Department 2002).

Comparisons will be made between PMAS training in GMP and the following forces: Cleveland, South Yorkshire, West Midlands and Merseyside. These forces have been chosen for comparison as they are in the same 'family of forces' as GMP (HMIC 1999). This' family of forces' is designed to allow data comparison across police forces (HMIC 1999). Information was supplied by the Health and Safety Department or Public Order Department of each force. Cleveland, West Midlands and Merseyside provided PMAS training data for the period January – December 2001. South Yorkshire was only able to supply PMAS training data from April 2001 to April 2002. In order to compare GMP to the 'family of forces' the following research hypothesis has been established.

Hypothesis 1: The injury rate during PMAS training in GMP will be different to the combined injury rate of the 'family of forces.'

Direct observations of training in other forces were not made, so it was not possible to calculate injury rates taking exposure into account in the same way they were for PMAS training in GMP. For the purpose of comparing PMAS training across different forces, injury rates were calculated per number of days exposure to training. The following formula was used:

$$\text{Injury Rate} = \frac{\text{number of injuries}}{\text{number officers trained} \times \text{number days training for each officer}}$$

Enquiries with forces from within the 'family of forces' reveal that some forces did not commence PMAS training until 2001. Also, the accuracy of the information available from some forces as regards the number of injuries and officers trained was less reliable prior to 2001 due to poor record keeping. For this reason it was thought a more accurate comparison of training across forces would be made if the records from 2001 were used

The second stage in the 'Sequence of Prevention' (Van Mechelen et al 1992) is establishing the aetiology and mechanism of injuries. In order to complete the second stage, 3 further hypotheses were formed:

Hypothesis 2: Some components of training will have a higher incidence of injury than others.

Hypothesis 2: Components of Training

Categories

1. Warm up.

2. Violent deranged person tactic.

3. Shield tactics (running line, junctions, withdraw, attack from the rear.)

4. Enclosed spaces (stairs, building entries.)

5. Tactical exercise.

6. Combined (petrol reception, cordon, vehicle tactics.)

Similar activities that are naturally related to each other have been grouped together, eg tactics that involve moving with a shield have been grouped together.

Hypothesis 3: Some mechanisms will be responsible for more injuries than others.

Hypothesis 3: Mechanism causing Injury

Categories

1. Struck by missile.

2. Hit by something other than missile (eg shield, bat.)

3. Collide with a stationary object.

4. Debris (injury caused by standing on debris.)

5. Fell other (Fall not as a result of debris.)

6. Sprain/strain (with no apparent initiating /aggravating factor.)

7. Other.

Hypothesis 4: Some parts of the body are more frequently injured than others.

<u>Hypothesis 4: Parts of Body Injured</u>

Categories

1. Foot and toe.
2. Leg and ankle.
3. Trunk.
4. Arm and wrist.
5. Hand and finger.
6. Neck and shoulder.
7. Head.

(The information available from source one has had a bearing on the choice of categories with the categories for parts of body injured replicating the categories of injury in source one.)

Statistical Analysis

The Chi square test has been recommended as a suitable test for analysing frequency data (Buncher 1988) (Kuhn, Greenfield, and Wojtgs 1997) and was used to test the hypotheses.

<u>Hypothesis 1</u>

Chi square was used to test the null hypothesis that there is no difference between the injury rate in GMP and the 'family of forces'. The analysis took exposure into account by using the following formula to calculate the expected frequencies for the Chi square test:

Expected Frequency For each Category	=	Total No. of Injuries in both Categories	x	% of Total No. of Officer Training Days for each Category

Hypothesis 2

Chi square analysis was used to test the null hypothesis that no one component of training will have a higher incidence of injury over any other. Exposure was taken into account by using the following formula to calculate the expected frequencies for the chi square test.

Expected Frequency for each Category	=	Total No. Injuries	x	% of Total Time Active for each Category

Hypothesis 3

Chi square was used to test the null hypothesis that no one mechanism of injury will be responsible for more injuries than any other.

Hypothesis 4

Chi square was used to test the null hypothesis that no part of the body is injured more frequently than any other.

It is not necessary to calculate exposure time for hypothesis 3 and 4 as an injury in the categories compared can occur at any time during the training. Significance for all the chi square tests was set at the .05 level which is standard practice (Crombie 2000)

There is much debate among statisticians as to the minimum number of expected frequencies required in each category to ensure a Chi square test is valid. Lewis and Burke (1949) suggest that expected frequencies of less than 5 invalidate the results of a Chi-square test. They recommend expected frequencies of 10 or above. In a review and update of the work by Lewis and Burke, Delucchi (1983) reports that there is some disagreement among statisticians as to the necessity for this rule. It was thought prudent however that for the purposes of this data analysis, some categories should be combined (i.e. petrol reception, vehicle tactics and cordons) to ensure that none of the categories in hypothesis 1 have an expected frequency of less than 10. These 3 tactics appear to be naturally related to each other, all having a low number of actual injuries during the period 1 April 1999 – 31 December 2001, less than 8. Also time active for all 3 Tactics is low, 21 minutes or less.

RESULTS

Description of the Injury Problem

Table 1 below shows the number of injuries during PMAS training on the paper records and on the computer records:

Table 1 Records of PMAS injuries

Period	Computer	Paper
April-Dec '99	88	65
2000	115	108
2001	97	76
Total	300	249

The number of injuries occurring during PMAS training between 1 April 1999 and 31 December 2001 are shown in table 2, along with the total number of officers trained. The basic injury rate has been calculated using the following formula:

$$\frac{\text{Number of Injuries}}{\text{Number of Officers Trained}}$$

Table 2 PMAS Injuries 1 April 1999 – 31 December 2001

	No. of Injuries	No. of Officers Trained	Injury Rate	% Rate
1 Apr – 31 Dec 1999	88	2754	.032	3.2
1 Jan – 31 Dec 2000	115	3761	.031	3.1
1 Jan – 31 Dec 2001	97	4,094	.024	2.4
1 Apr 99 – 31 Dec 2001	**300**	**10609**	.028	2.8

Hours Active

A description of the different components of training observed over the two day period follows. Visual representations of some of the components are shown at appendix G. Forty two officers were observed on two consecutive days in February 2002. The officers were split into two units of 20 and 22 respectively. Hours active per person was calculated for the following components of training.

Warm Ups

Two warm ups were observed, one at the beginning of each day. The warm-ups consisted of pulse raising and mobilising activities combined with static stretching. The first warm up lasted 7 minutes, 28 seconds. The second warm up lasted 12 minutes, 32 seconds. All students were active throughout the warm up.

Total Warm Up Time = 20 Mins

Hours Active per Person = $\frac{20}{60}$ = .33 hrs

Violent Deranged Person (VDP) Tactic

The VDP was armed with a baseball bat. A unit of 3 officers, two holding shields and one 'backup officer' behind the two shield officers, enter the room. The technique is to drive the VDP into a corner of the room and pin him or her against the wall so he/she can be disarmed and restrained. The VDP violently strikes the officer's shields, but doesn't deliberately attempt to strike the officers for safety reasons. While this is taking place, a second shield unit is formed up at the entrance to the room, ready to move in if required. This tactic lasts for 45 minutes. During this tactic not all students are active at one time, the majority are watching. To calculate hours active, the following rationale has been used. The unit containing 22 officers was observed. The instructor was included in the exercise making a total of 23. The VDP and all 3 members of the shield team are obviously active. The second shield team who cover the entrance and act as back up are also considered active because they are crouched behind shields in a doorway, which is a potential source of injury. Therefore only 7 out of 23 people were considered to be active during this exercise at any one time. Hours active was calculated as follows:

$$\frac{7}{23} \times 45 \text{ Mins} = 13 \text{ Mins } 42 \text{ Secs}$$

$$\text{Hours Active per Person} = \frac{13.7}{60} = .23 \text{ hrs}$$

Shield Tactics

During this tactic students practice marching with shields in units and forming shield lines. During this tactic, wooden blocks are thrown at the shields by instructors. Included within shield tactics are three specific tactics; *running lines, attack from the rear and junctions*. In essence all these tactics are the same. The timings for *running lines and attack from rear* was 54 minutes. The timing for *junctions* - 33 mins. All 20 students in the unit were engaged throughout the tactic. Students occasionally stopped during the tactic to receive instructions from the public order trainers. The maximum time stood listening to the trainers was less than one minute and during this time students were still holding shields which is a potential source of injury. The students were therefore considered active throughout 87 minutes.

$$\text{Hours Active per Person} = \frac{87}{60} = 1.45 \text{ hrs}$$

Enclosed Spaces

The two tactics that make up the enclosed spaces tactic are *buildings entries* and *stairs*. At various points during the performance of these tactics, wooden missiles are thrown at the shields of the officers taking part by a public order trainer. The hours active were calculated using the following rationale. The unit of 20 students were watched performing stair tactics. The tactic took a total of 18 mins 55 sec's. For 6 mins 20 sec's only 3 officers were involved as a demonstration team:

$$\frac{3}{20} \times 6 \text{ mins } 20 \text{ secs} = \frac{3}{20} \times 380 \text{ secs} = 57 \text{ secs}$$

All 20 officers were involved in stair tactic for 12 mins 35 sec's.

12 mins 35 secs + 57 secs = 13 mins 32 secs

Total Time Active for *Stair Tactic* = 13 mins 32 secs

The unit of 22 students was watched performing *building entries*. The tactic took a total of 34 mins 40 seconds. For 5 mins 30 sec's only 8 officers were involved as a demonstration team.

$$\frac{8}{22} \times 5 \text{ mins } 30 \text{ secs}$$

$$\frac{8}{22} \times 330 \text{ secs} = 120 \text{ seconds} = 2 \text{ mins}$$

All officers were involved in the building entry tactic for 29 mins 10 sec's.

29 mins 10 secs + 2 mins = 31 mins 10 secs

Total time active *building entries* = 31 mins 10 secs

The total time active for *stair tactics*

and *building entries* was combined = 44 mins 42 secs

$$\text{Hours Active per Person} = \frac{44.7}{60} = .74 \text{ hours}$$

Tactical Exercise

One unit acted as police officers and the other unit acted as rioters. All rioters and police officers are active throughout the exercise.

Total Time on Tactical Exercise = 45 mins 40 seconds

Hours Active per Person = $\frac{45.66}{60}$ = .76 hour

Combined (Petreol reception, cordon, vehicle tactics)

During petreol reception tactic teams of three advance through fire on the ground which is ignited by petrol. Each team goes through twice. All 42 students take part. The tactic took a total of 20 minutes. Three teams of three people (n = 9) were active. One team formed to enter petreol reception area, one team performed the tactic and one were leaving the petreol reception area.

Hours active was calculated as follows:

$\frac{9}{42}$ x 20 Mins = 4 Mins 18 Secs

Hours Active per Person = $\frac{4.3}{60}$ = .07 Hours

During the cordon tactic officers practiced marching as a unit and forming cordons. This tactic took 21 minutes and all students are involved throughout the tactic.

Hours Active per Person = $\frac{21 \text{ Mins}}{60}$ = .35 Hours

During the vehicle tactics officers with shields boarded personnel carriers. The vehicles drove into the training area and the occupants evacuated the personnel carrier and formed a shield line in the street. All 42 students took part in the tactic. Acting as two units, one unit watched while the other performed the tactic. Each unit performed the tactic 3 times, alternating between watching and taking part. Hours active was calculated as follows: Total time spent on tactic = 35 minutes

$35 \div 2 = 17.5$ Mins or 17 Mins 30 Secs

Hours Active per Person $= \frac{17.5}{60} =$ .29 Hours

The total of hours active is shown in table 3.

Table 3

Training Component	Hours active per Person
Warm Up:	.33
VDP:	.23
Shield Tactics:	1.45
Enclosed Spaces:	.74
Tactical Exercise:	.76
Petreol Reception}:	.07
Cordon }: Combined	.35
Vehicle Tactics }:	.29
Total	4.22 hours

Incidence of Injuries per 1000 hrs

The formula described earlier, adapted from Chambers, can now be used to calculate the incidence of injuries per 1000 hours of PMAS training during the period 1 April 1999 – 31 December 2001:

$$\frac{300 \quad \times 10^3}{10609 \times 4.22} = 6.7 \text{ Injuries per 1000 Hrs}$$

Comparison between GMP and the family of forces

A comparison between injury rates during GMP PMAS training and training in other forces is shown in table 4. The formula used to calculate the injury rate for this comparison has been described earlier.

Table 4 Incidence of injuries PMAS training

Force	Period	No. Officers Trained	Length of Course (Days)	Total No. of Officer Training Days	No. of Injuries	Rate (Injuries per Day)
Cleveland	Jan-Dec 2001	200	4	800	10	.0125
S. Yorkshire	April 2001 – April 2002	375	5	1875	33	.0176
W. Midlands	Jan – Dec 2001	-	-	11033	42	.0038
Merseyside	Jan – Dec 2001	1850	2	3700	83	.0224
GMP	Jan-Dec 2001	4094	2	8188	97	.0118
Total	-----	------	------	25596	265	------

West Midlands police could not provide a breakdown of the number of officers trained and the length of the course but were able to supply the total number of officer training days.

The average injury rate of the family of forces excluding GMP is as follows:

$$\frac{\text{Total No. of Injuries across Family of Forces}}{\text{Total No. of Officer Training Days across Forces}} = \frac{168}{17408}$$

Rate Injuries per Day = .0096

The Chi square analysis was used to test the null hypothesis that there is no difference between the frequency of injuries in GMP and the other forces combined (Hypothesis 1). Table 5 below shows the expected and actual frequencies of injury.

Table 5 **Expected and actual frequencies of injuries in GMP and other forces combined**

Forces	Expected Frequencies	Actual Frequencies
GMP	84.8	97
Other Forces Combined	180.02	168

The result of the Chi square analysis is shown in Appendix B. The result is not significant (p = 0.108). Therefore the null hypothesis that there is no difference between the frequency of injuries in GMP and the other forces combined cannot be rejected. There is not a statistically significant difference between the number of injuries occurring during PMAS training in GMP and the other forces to which it has been compared.

Components of PMAS training during which injuries occur

Table 6 shows the number of injuries in each category of PMAS training obtained from Source 2, (paper records).

Table 6 Number of injuries PMAS training

Category	1999	2000	2001	Total	Percentage
Warm Up	6	12	6	24	9.6
VDP	8	16	8	32	12.8
Shield Tactic	5	16	19	40	16.1
Enclosed Spaces	7	12	8	27	10.8
Tactical Exercise	36	40	27	103	41.4
Petrol Reception	1	2	4	7	2.8
Cordons	0	0	0	0	0
Vehicles	0	1	1	2	0.8
Other	2	8	2	12	4.8
Unknown	0	1	1	2	0.8
Total	65	108	76	249	

The category unknown is for injuries that were recorded with insufficient information to establish when the injury occurred. The category 'other' is for injuries that occurred during the 2 day PMAS training but not during any of the activities or tactics being examined. For data protection reasons, GMP have requested that the specific details of injuries in the category 'other' should not be described due to the possibility of individual identification.

The categories unknown and 'other' have not been included in any data analysis.

Table 7 shows the incidence of injury in each category of PMAS training for the period 1st April 1999 – 31st December 2001. 10,609 officers were trained during this period. Incidence has been calculated per 1000 hrs using the formula adapted from Chambers to take exposure into account.

Table 7 Incidence of injury by category PMAS training

Category	Number of injuries	Hours active (per person)	Incidence (per1000hrs)
Warm Up	24	.33	6.85
VDP	32	.23	13.11
Shield Tactic	40	1.45	2.6
Enclosed Spaces	27	.74	3.44
Tactical Exercise	103	.76	12.77
Combined, Cordons, Vehicles, Petrol	9	.71	1.19

Chi-square analysis was used to test the null hypothesis that there is no difference in the number of injuries occurring during the different categories of PMAS training (hypothesis 2). Table 8 below shows the expected and actual frequencies of injury.

Table 8 Injury frequencies from paper records

Category	Time active in seconds	% of total time active	Expected frequency	Actual frequency
Warm Up	1200	7.88	18.5	24
VDP	822	5.4	12.7	32
Shield Tactic	5220	34.27	80.5	40
Enclosed Space	2682	17.61	41.4	27
Tactical Exercise	2740	17.99	42.3	103
Combined	2568	16.86	39.6	9
TOTAL	**15232**		235	235

The result of the Chi-square analysis is shown in Appendix C. The result is highly significant (p < 0 .0005).

Therefore the null hypothesis that there is no difference between the number of injuries occurring in each category of PMAS training can be rejected.

Mechanisms of Injury

Table 9 shows the different mechanisms of injury during PMAS training from 1 April 1999 – 31 December 2001 obtained from Source 2 (paper records).

Table 9 Mechanisms of Injury

Mechanisms of injury	Number of injuries	Percentage total
Struck by missile	95	38
Hit by something other than missile	20	8
Collide with stationary object	11	4
Debris (standing on)	30	13
Fell, other	11	4
Sprain, strain. no 1 initiating factor	58	23
Other	20	8
Unknown	4	2
Total	**249**	**100**

For data protection reasons GMP have requested that the specific details of injuries in the category 'other' are not described due to the possibility of individuals being identified. The category unknown has not been included in the data analysis. Chi square analysis was used to test the null hypothesis that no one mechanism of injury will be responsible for more injuries than any other (hypothesis 3).

The result of the Chi-square analysis is shown in Appendix D. The result is highly significant ($p < 0.0005$). Therefore the null hypothesis that there is no difference between the number of injuries caused by each mechanism can be rejected.

Parts of Body Injured

Table 10 below describes the number of injuries by body part, between 1 April 1999 – 31 December 2001, obtained from Source 1 (computer records).

Table 10 Number of injuries by body part

Body part	Number of injuries	Percentage
Foot and toe	39	13
Leg and ankle	108	36
Trunk	32	11
Arm and wrist	42	14
Hand and finger	32	11
Neck and shoulder	30	10
Head, inc. eyes	11	3.
Unknown	6	2
Total	**300**	**100**

The category unknown is not included in any data analysis.

Chi square analysis was used to test the null hypothesis that no part of the body is injured more frequently than any other. The result of the Chi-square analysis is shown in Appendix E.

The result is highly significant ($p < 0.0005$).

Therefore the null hypothesis that no part of the body is injured more frequently than any other can be rejected.

DISCUSSION

Between 1st April 1999 and 31st December 2001 10,609 officers participated in PMAS training in GMP. Three hundred injuries were documented. The rate of injury was calculated taking into account exposure. Four hypotheses were proposed and tested. The injury rate in GMP was compared to the injury rates in other police forces that make up the 'family of forces.' The various components of PMAS training were studied to see if any one component was more likely to result in injury than any other. The mechanisms of injury during PMAS training were also studied to identify any mechanism that was responsible for more injuries than others. Parts of the body that were injured more than others were identified. Recommendations based on the findings of the study will be made that may help reduce the risk of future injuries.

Comparison between PMAS training in GMP and other forces

The rate of injuries per day in GMP was found to be 0.0118. When compared to other police forces the results were not significant (hypothesis 1). It is suggested that the most accurate way of describing the injury problem is the comparison between PMAS training in GMP and other forces. This is because not only are the activities virtually the same, but also the injury definitions and injury reporting systems used across police forces are broadly similar. Therefore, many of the difficulties previously highlighted when comparing across studies are eliminated.

Incidence of Injury during other Sporting Activities

A comparison is now made between the injury incidence rates in PMAS training and other sports and recreational activities. These comparisons must be viewed critically due to differences in terminology and definitions across different studies. A study by

Requa et al (1993) into injuries during adult recreational fitness participation reported an overall injury rate of 7.83 per 1000 hours of participation. This study used two injury definitions, one being 'time loss' and one being 'any injury reported.' The second definition which is more sensitive, records a higher number of injuries and is similar to the definition of injury for PMAS training. The rates reported here for comparison are the ones using the 'any injury reported' definition. Adults participating in competitive contact sports recorded the highest injury rates. Adults taking part in cardiovascular fitness activities, such as cardiovascular exercise machines, had lower injury rates. The injury rate for 1,000 hours for PMAS training in GMP was 6.7 which compares favourably. Table 11 shows a sample of the activities studied.

Table 11

Activities	**Rate per 1000 hrs**
Stationary cycles	1.77
Stair climbers	2.95
Resistance/weight machines	4.00
Treadmills	6.36
Rowing machines	7.06
Above gym based activities combined	4.43
Tennis	7.74
Running – not on treadmills	14.73
Basketball	18.5
Rugby	60.0
GMP PMAS	6.7

A review of injury studies in martial arts by Willy (1996) reported that studies varied widely in respect of injury definitions and the methods used to calculate injury rates. Only one study reviewed provided exposure data. This was a study into injuries during non contact karate by Kurland (1980). Injury rates of 18.4 per 1000 hours were reported. Lysholm and Wiklander (1987) carried out a study of injuries to runners which was reviewed in the methods section of this dissertation. They reported injuries per 1000 hrs of training. Long distance/marathon runners recorded injury rates of 2.5 per 1000 hrs. Sprinters and middle distance runners recorded injury rates of 5.8 per 1000 hrs. The definition of injury for this study was 'any injury that markedly hampered training or competition for at least one week'. This definition is less sensitive than the one used for PMAS training and therefore less likely to record some minor injuries that would be recorded during PMAS training. This could also account for the difference in 'running not on treadmills' which recorded an injury rate of 14.73 injuries per 1000 hrs (Requa et al 1993). Junge and Dvorak (2000) carried out a study of soccer injuries. The injury rate in their study was 7.3 per 1000 hrs of exposure. The definition of injury used by Junge and Dvorak was defined as "any tissue damage caused by football, regardless of subsequent absence from games or training sessions". This definition is sensitive to minor injuries which would not be recorded if absence from games or training was included in the definition.

The overall injury rate in GMP PMAS training compares favourably with some activities such as team sports, rugby, basketball and martial arts but less favourably with recreational activities such as gymnasium based fitness activities.

PMAS Training Components and Mechanism of Injuries

Three further hypotheses were tested in this study and the null hypothesis was rejected in each case.

The highest incidence of injuries taking exposure into account, occurred in the violent deranged person (VDP) component. This accounted for 13.11 per 1000 hours. The second highest incidence of injury occurred during the Tactical exercise component which accounted for 12.77 injuries per 1000 hours. The warm up, enclosed spaces, shield tactic and combined (cordons, vehicles, petreol) components accounted for incidences of 6.85, 3.44, 2.6 and 1.19 injuries per 1000 hours respectively. Being struck by a missile was the most common cause of injury. 95 injuries occurred in this category.

When combined the foot and toe and leg and ankle categories account for 147 injuries. This is half all injuries recorded. The significance of a high number of lower limb injuries will be discussed later.

Injury Recording and Exposure

It is acknowledged that the methods used in this study are more sensitive compared to methods used in other studies. For example, the definition of injury and the methods used to record injuries mean that even the most minor injuries were recorded in this study. Also the very exact calculation of participation using detailed observations will under estimate exposure time compared to some other studies. All the information needed for a reader to interpret the data, draw conclusions and make comparisons has been included and described in this study (definitions of injury and exposure, statistical techniques, calculations and methods of data collection).

One full PMAS training package over a two day period was observed to estimate exposure. This method of estimation is based on the fact that all officers attending PMAS training receive the same training package (Greater Manchester Police Public Order Training Department 2002). It is therefore assumed that the same amount of time is spent on each activity every time officers train. In reality times may vary slightly and the only way to calculate exposure exactly would be to observe every session of PMAS training and calculate the times. This is not only impracticable but also impossible in a retrospective study. All methods of estimating exposure have their flaws and it is suggested that the method used here is more accurate than other studies discussed in the literature review section of this dissertation.

Cause and Prevention

It is difficult in epidemiological studies to establish a causal relationship between a risk factor and an injury Meeuwise (1991). A relationship between two variables could in fact be due to a third variable. Fletcher, Fletcher and Wagner (1982) point out that the presence of a third factor or confounding variable does not diminish the value of the risk factor as a way of predicting injury if the factors are known to occur together in a reliable fashion. Injuries are usually the result of a combination of risk factors (Caine, Caine and Lindner 1996). Risk factors can generally be divided into 2 categories, internal/personal factors and external/environmental factors (Miles 1997). This dissertation has analysed external factors only. Internal factors are equally important and could be the subject of future studies. Van Mechelen, Hlobil and Kemper (1992) suggested a list of possible internal and external factors that could play a part in sports injuries. The following list is largely based on the list compiled by Van Mechelen et al with some of the external factors changed to make the list more relevant to PMAS training.

Risk Factors which May Play a Part in PMAS Training Injuries (RFPMAS)

Internal

Physical defect

Physical fitness

- Aerobic endurance
- Strength
- Speed
- Coordination
- Flexibility

Previous Injury

Physical Build

- Height
- Weight
- Joint stability
- Body fat

Sex

Age

Psychological Factors

- Self concept
- Risk acceptance
- Personality
- Motivation
- Trainer knowledge/skills

External

Training related factors

- Tactic
- Exposure
- Role of opponents
- Role of team mates

Venue

- State of floor
- Debris on floor
- Lighting
- Safety Measures
- Temperature
- Humidity

Equipment

- Clothing e.g. boots, overalls, belts.
- protective equipment
- Tools e.g. shields missiles, baseball bat, petrol.

Trainer

- Trainer control
- Trainer application of rules

The RFPMAS list is suggested as a guide when considering future prevention strategies for PMAS training.

Having introduced preventative measures, the next step in the sequence of prevention proposed by Van Mechelen et al (1992) would be to assess the effectiveness of those preventative measures. The effectiveness of a preventative measure can most reliably be determined by employing an intervention study (also known as experimental study or a clinical trial) (Hennekens and Buring 1987). In PMAS training this would involve subjects being randomly assigned to two groups. One group would train with the preventative measures in place, the other would not. After a period of time, comparisons would be made between the number of injuries in both groups to ascertain if there was a significant difference in the number of injuries. In practice there has been very little research to carry-out the effectiveness of injury prevention methods in sports epidemiology. This is most probably due to a combination of ethical, cost and feasibility issues (Caine et al 1996). Caine et al report that there is also very little quasi-experimental research in to the effectiveness of preventative measures. The combination of ethical, cost and feasibility issues also make it unlikely that preventative measures introduced during PMAS training could be scientifically tested. Caine et al point out that many preventative methods implemented have reduced sports injuries, even though their effect has not been subjected to strict scientific evaluation as suggested by Hennekens and Buring.

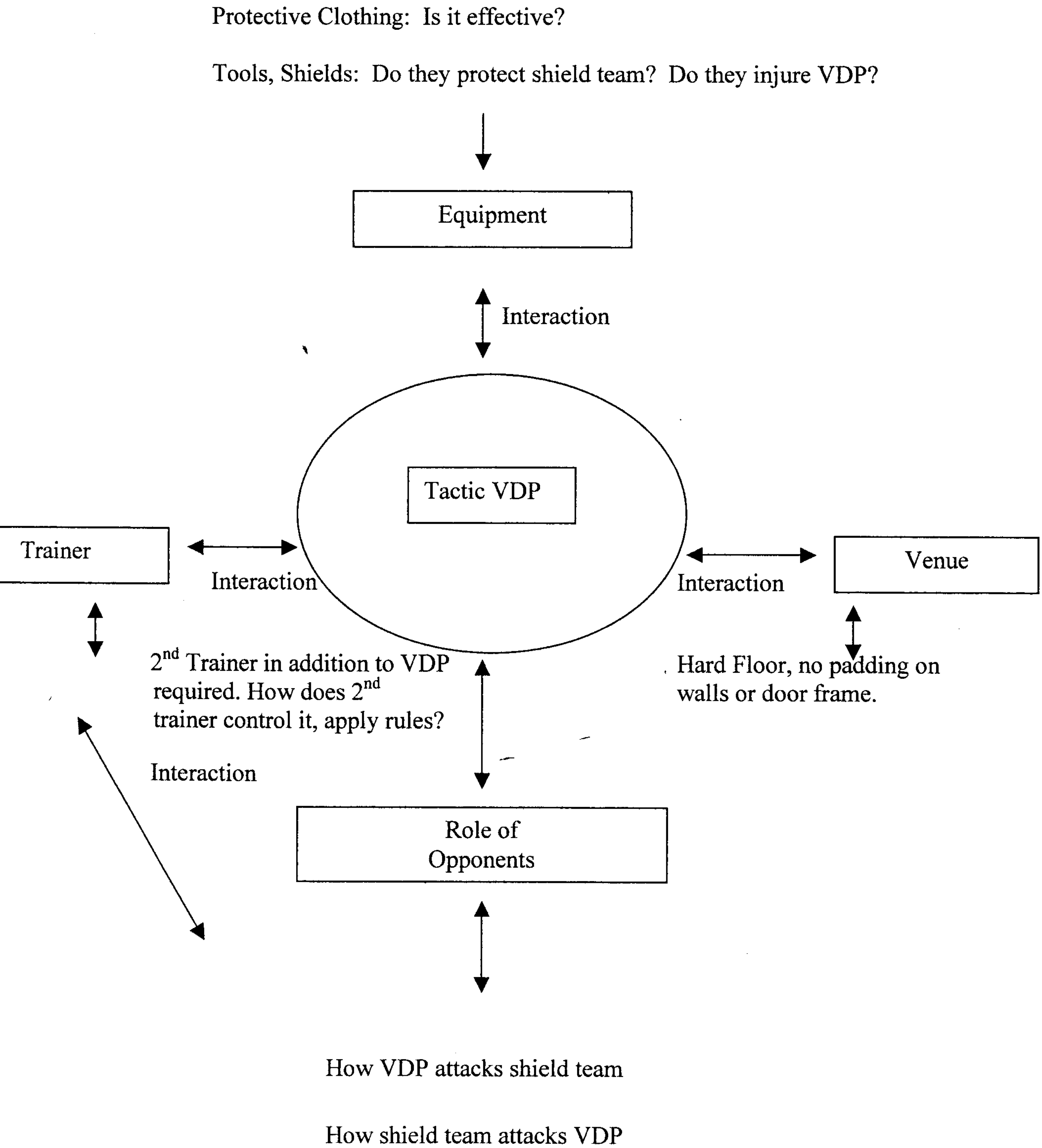
Possible Causes of Injury during PMAS Training

In this section, suggestions will be made as to how the information obtained from the three hypotheses and the RFPMAS list can be used to identify external factors and interactions that may be responsible for injuries during PMAS training. Observations of public order training have influenced the suggestions made. Public order trainers, using their expertise and experience may be able to improve on the suggestions made. The information can then be used to guide future injury prevention strategies.

VDP

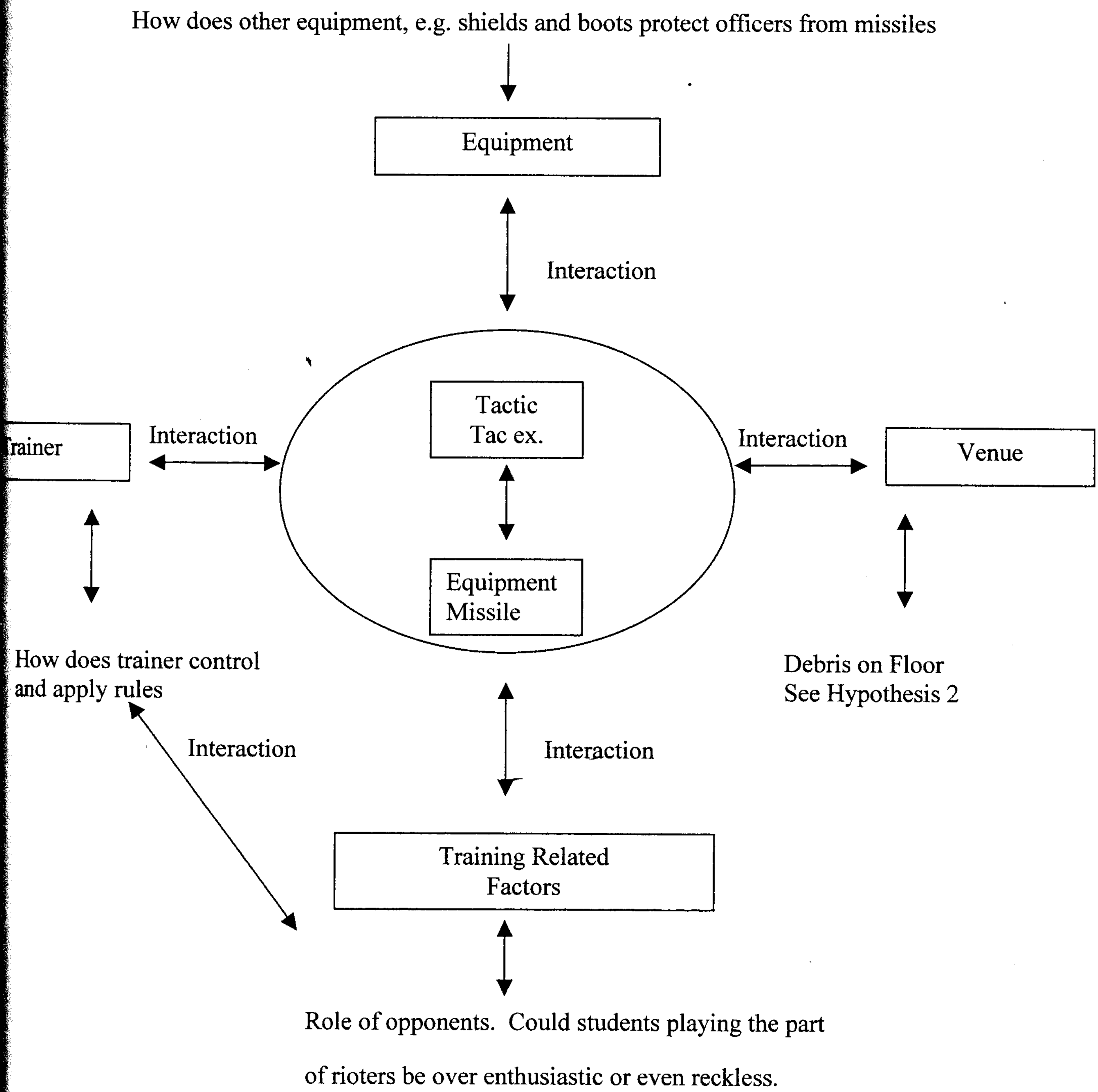
The VDP is the component of training with the highest incidence of injury. A public order trainer always plays the role of the VDP as a safety measure.

The VDP is overcome in this exercise by being rammed into a wall by officers with shields and then taken to the floor. The RFPMAS diagram below is a suggestion as to how the different factors in the RFPMAS list could have interacted during the VDP component to produce injuries.


Protective Clothing: Is it effective?
Tools, Shields: Do they protect shield team? Do they injure VDP?
Equipment
Interaction
Tactic VDP
Trainer
Interaction
Venue
Interaction
2nd Trainer in addition to VDP required. How does 2nd trainer control it, apply rules?
Hard Floor, no padding on walls or door frame.
Interaction
Role of Opponents
How VDP attacks shield team
How shield team attacks VDP

Tactical Exercise

The tactical exercise was the component of training with the second highest incidence of injury. One apparent interaction of factors from the RFPMAS list could be this tactic and the use of missiles. This study identified being struck by a missile as the most common cause of injury. Observations of PMAS training reveal that the vast majority of missiles are thrown during the tactical exercise. During this component large numbers of missiles are thrown by fellow students playing the role of rioters. It can be seen how virtually all the other factors in the RFPMAS list could be considered in conjunction with ' tactic', and 'missiles' to form a strategy to prevent injuries during the tactical exercise. The RFPMAS diagram below is a suggestion as to how the different factors in the RFPMAS list could have interacted to produce injuries during the tactical exercise.


How does other equipment, e.g. shields and boots protect officers from missiles
Equipment
Interaction
Tactic
Tac ex.
Equipment
Missile
rainer
Interaction
Interaction
Venue
How does trainer control
and apply rules
Debris on Floor
See Hypothesis 2
Interaction
Interaction
Training Related
Factors
Role of opponents. Could students playing the part
of rioters be over enthusiastic or even reckless.

Warm Up

Warm up was the component of training with the third highest incidence of injury. What raises cause for concern over the warm up is that unlike the VDP and tactical exercise components, a lot of injuries would not be expected during a warm up. The VDP and tactical exercise components are violent activities and due to their nature carry an inherent risk of injury. The purpose of a warm up is to reduce the chance of injury and improve performance (Bean 1997). The 'Dictionary of Sport and Exercise Sciences', defines a warm up as follows:

> "A low intensity activity that generally consists of exercises to increase the body temperature and light stretching done to elevate the physiological state in preparation for intense activity; may help reduce the incidence of muscular skeletal injury" (Anshel 1991).

In view of the nature and purpose of a warm up, measures could and should be taken to reduce the number of injuries during this activity. A brief review of the literature relating to warming up prior to exercise follows. The recommendations made at the end of this study have been influenced by the literature discussed.

The conventional suggested structure of a warm up as recommended by Bean (1997), Allerheiligen (1994), Alter (1996), Williams (1998) and Pearson (1998) is as follows; mobilisation exercises to release the synovial fluid between joints, low intensity aerobic activity to raise body temperature and increase the supply of blood to the muscle, short static stretches for each muscle group and finally a re-warm activity is recommended after cooling down due to the static stretching. This re-warm activity may include specific exercises for the activity that is to follow.

The value of the stretching component of a warm up has been questioned. Knudson (1999) carried out a review of the literature regarding the benefits of stretching during warm ups. Knudson concluded that there was a lack of scientific evidence supporting the injury preventing or performance benefits of stretching during warm up for most activities. The review by Knudson provided evidence to support his conclusion. However, the author did not state how papers were identified for inclusion in the review, thereby raising the possibility that the papers included in the review may be biased towards one point of view.

Anderson (2000) also reports that there is a lack of scientific evidence in terms of randomised controlled trials and cohort studies to support the theory that stretching, as part of a warm up, is an effective way of preventing injury. Anderson points out that cohort studies are most common in the scientific literature and that those studies are subject to considerable bias, which can significantly distort the results.

Smith (1994) in a review of the literature concluded that there was evidence to support the theory that stretching, as part of a warm up, reduced injury. Smith uses evidence in the literature on the increased flexibility due to stretching to support his belief that stretching helps reduce injury. In his review, Smith does not state how papers were identified for inclusion, raising the possibility that the papers included may be biased.

Travisano (2002) describes the scientific research into warm ups as very equivocal. The logic for including stretching in a warm up is that loosening the muscles and connective tissues should make them less susceptible to excessive strain (Anderson 2000). Biomechanical studies have shown that there are short term increases in flexibility from stretching (McHugh et al 1992) (Pollock et al 1998). Based on the biomechanical evidence Williams (1998) argues that although there is no significant scientific evidence to state you need to stretch in a warm up, it is both logical and appropriate to do so in order to be fully prepared for the activity. If a stretching is to be included in a warm up for PMAS training, the trainers need to be aware of the following issues:

1. Most researchers recommend static stretching as opposed to ballistic stretching, as there is less chance of injury. (Williams 1998), (Pollock et al 1998), (Smith 1994), (Bean 1997), (Alter 1996), (Knudson 1999)

2. Most researchers recommend that the body temperature should be elevated by pulse raising activities prior to stretching, as stretching a cold muscle could cause injury. (Williams 1998), (Smith 1994), (Bean 1997), (Alter 1996), (Knudson 1999)

3. There is evidence that some stretches may be dangerous, because they create body positions that stretch ligaments or create loads that are potentially injurious. (Lindsey and Corbin 1989), (Lubell 1989), (Alter 1996), (Maher 2001)

Trainers need to be aware of controversial or contraindicated exercises. One example of such an exercise is the common toe touching exercise to stretch the hamstrings. Maher (2001) identified forward flexion of spine with straight legs as an exercise commonly performed during warm ups by GMP self defence trainers. Maher concluded that this exercise had the potential for causing back injuries and should not be used during self defence training in GMP.

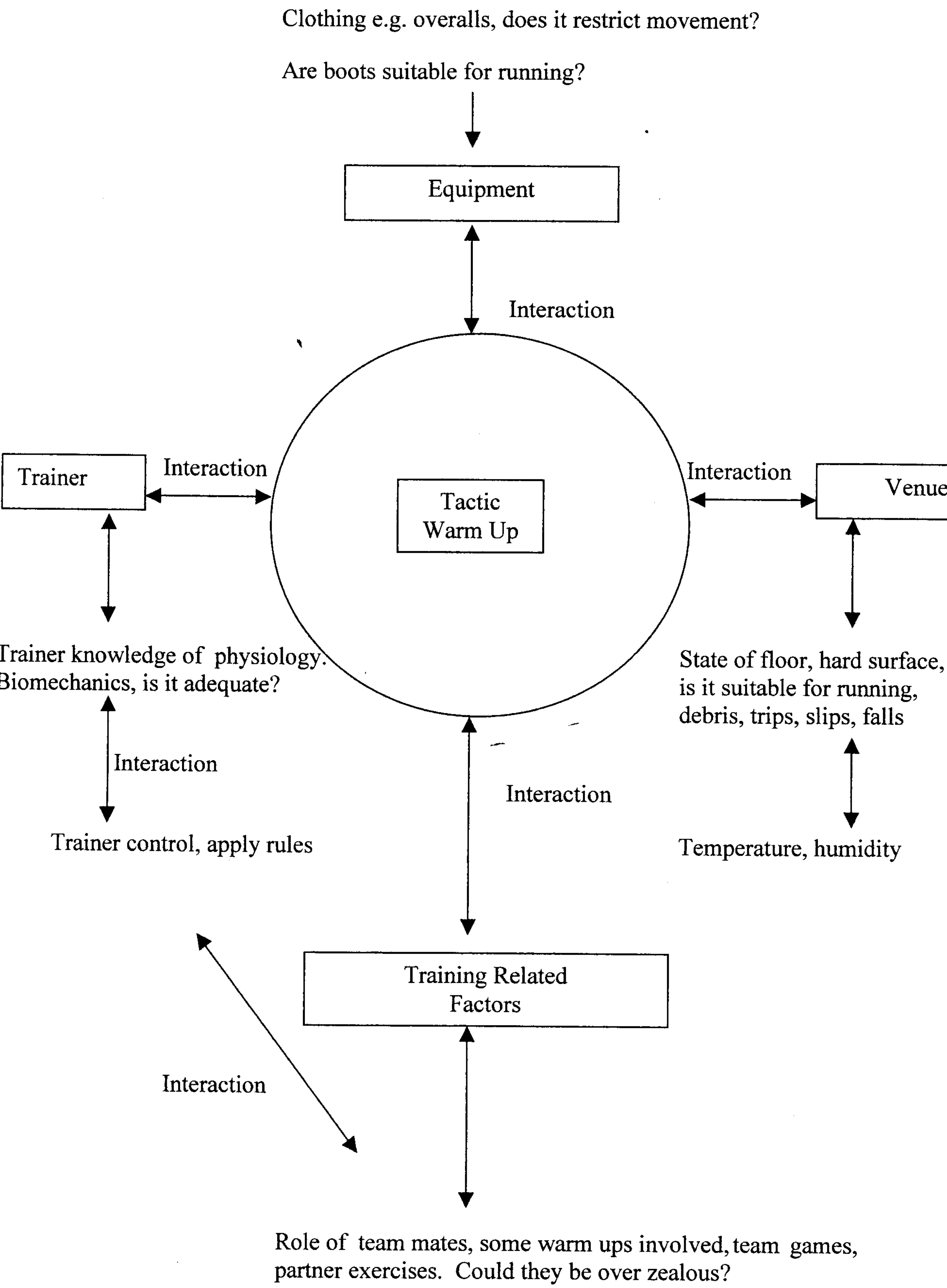
Another consideration when considering a warm up is the risk of cumulative strain. Cumulative strain can be defined as repetitive acts which incorporate poor posture or movement (SCPHS 2000) Winter and Bishop (1992) use the term chronic injuries for cumulative injuries. They describe injuries as falling into two categories:

1. Single event injuries resulting from a recognised traumatic incident.

2. Chronic injuries which are caused by repetitive damaging forces which are below the single event injury threshold.

Trainers are in a powerful position and can influence the future conduct of their students. It is therefore desirable that trainers do not demonstrate exercises which include poor postures or movement, as students may adopt these exercises for their future use (Maher 2001). This is an additional reason why trainers should have a knowledge of controversial or contra indicated exercises.

A number of observations have been made of warm ups during PMAS training. The warm ups observed have tended to vary markedly from one another in terms of structure and timing. The RFPMAS diagram below is a suggestion as to how the different factors in the RFPMAS could have interacted with the warm up to produce injuries.


Clothing e.g. overalls, does it restrict movement?
Are boots suitable for running?
Equipment
Interaction
Trainer
Interaction
Tactic
Warm Up
Interaction
Venue
Trainer knowledge of physiology.
Biomechanics, is it adequate?
Interaction
Trainer control, apply rules
State of floor, hard surface,
is it suitable for running,
debris, trips, slips, falls
Temperature, humidity
Interaction
Training Related
Factors
Interaction
Role of team mates, some warm ups involved, team games,
partner exercises. Could they be over zealous?

Lower Limb Injuries

There were 147 lower limb injuries. This is 50% of the total number of injuries. It is not surprising that most of the injuries have occurred in the lower limb, as the lower extremity of the body is involved in virtually all athletic movements (Winter and Bishop 1992). Winter and Bishop divide the task of the lower extremities into five subtasks; these are shock (energy) absorption, control of vertical collapse during any phase of weight acceptance, balance and posture control of the upper part of the body, generating energy associated with forward and upward propulsion and control of direction changes of the centre of mass of the body.

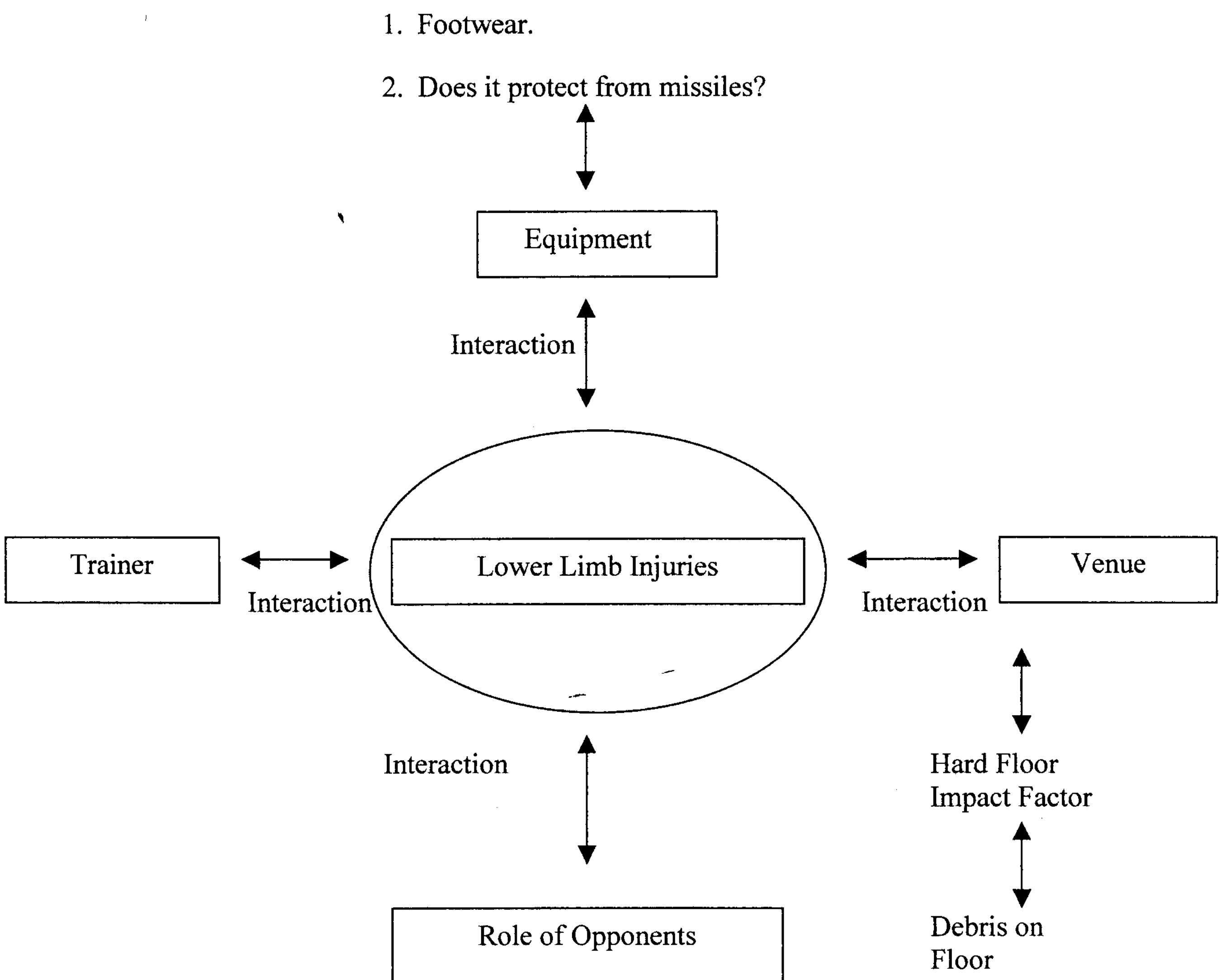
A muscle or muscle group can be involved in a number of these subtasks at the same time (Winter and Bishop 1992). Much of the research into lower limb injuries involves studies of running injuries. The evidence from these studies is a useful indication as to possible causes of injury during PMAS training. Smith (1980) reports that terrain is a possible factor in lower limb injuries. Smith describes the ideal surface as being flat, smooth resilient and reasonably soft. Smith states that a hard surface increases impact forces, while running uphill increases pronation of the foot. Smith states that impact forces and over pronation of the foot can both cause injuries. Nigg (1986) compared running on grass to running on asphalt. Nigg also concluded that running on soft surfaces reduced injuries due to less impact forces. Another factor that has been examined in relation to lower limb injuries is footwear. Taunton, McKenzie and Clement (1988), Drez (1980) and McLatchie (1993) report that running injuries can be reduced by shoes with shock absorbing qualities.

One of the few studies that examined the effect of boots on injuries was carried out by Milgrom, Firestone and Shlamkovitch (1992). Milgrom et al investigated the effect of improved shock attenuation using modified basketball shoes compared to infantry boots. A comparison of overall incidence of injuries showed a statistically significant ($p < 0.05$) lower incidence rate in a group wearing basket ball shoes compared to a group wearing infantry boots. Although a direct comparison between infantry boots and boots used during PMAS training has not been made, it is cautiously speculated that there are similarities between the two. Robins and Gouw (1990) do not advocate shoes with shock attenuating qualities. They report that shoes which attenuate shock absorption reduce sensory feedback through the foot which causes runners to adversely alter their running style, thereby causing injuries.

Stacoff, Kalin and Stussi (1991) report that over pronation of the foot causes injuries in runners. Stacoff et al conclude that reduced stiffness of the shoe sole in the longitudinal direction reduces pronation and may reduce injuries. Stacoff et al also recommend that a shoe should have an elevated heel. McKenzie, Clement and Taunton (1985) also report that excessive pronation of the foot causes injuries and recommends an elevated heel in the shoe sole to reduce over pronation.

In summary the evidence indicates that terrain and footwear may be factors in lower limb injuries. Soft level surfaces reduce impact forces and over pronation of the foot. Footwear appears to be a factor in lower limb injuries but the ideal footwear for PMAS training would need further study.

The RFPMAS diagram below is a suggestion as to how the factors in the RFPMAS list could have interacted to produce lower limb injuries:



CONCLUSIONS

There was a total of three hundred injuries during PMAS training in GMP between 1st April 1999 and 31st December 2001. Injury rates during PMAS training across police forces are similar. Whilst bearing in mind the difficulties of comparing across studies, it appears that PMAS training, considering its nature, compares favourably with other adult recreational activities reviewed in this dissertation. Injury prevention is an issue which is taken seriously by the management and staff of the public order training department and the department already carries out risk assessments and implements safety measures, as they are legally required to do so under the HASAWA 1974 (Roberts-Phelps 1999). It is suggested that the information in this study, obtained from the hypotheses tested and the RFPMAS list can guide the updating of risk assessments and the implementation of future safety measures.

The following issues are highlighted as priorities for future preventative strategies:

1. Certain components of training have a greater incidence of injury than others The VDP tactic and the tactical exercise are the two components with the highest incidence of injury.

2. The warm up has been identified as having a high incidence of injury considering its purpose and nature. As such, this component of training warrants further attention.

3. Being struck by a missile has been identified as the mechanism responsible for the majority of injuries. Observations of PMAS training reveal that the vast majority of missiles are thrown during the tactical exercise and therefore it is likely that there is a strong

interaction between the tactical exercise and being struck by a missile.

4. The part of the body most often injured is the leg and the ankle. Footwear and terrain are possible factors involved in lower limb injuries.

RECOMMENDATIONS

The priorities outlined in the 'Conclusions' section form the basis of the following recommendations:

General Recommendations

It is recommended that analysis of the issues highlighted are carried out with a view to updating safety measures and risk assessments. It is suggested that the RFPMAS diagrams in the 'Discussion' section of this report form a useful frame work for analysing the interaction of risk factors that may be responsible for injuries. Specialist trainers should be involved in the analysis and should use their knowledge and experience to develop the RFPMAS diagrams.

Warm Ups

It is recommended that warm ups remain as part of PMAS training. Stretching is the most debated component of warm up procedure in the literature. A future randomised controlled trial of the benefits of stretching during PMAS warm ups could be enlightening and scientifically very valuable. In the meantime it is recommended that the stretching component remains as part of the warm up procedure. Two alternatives are suggested to prevent injuries during the warm up:

(i) A study of PMAS training and warm ups is made by a suitably knowledgeable person. This person should then put together a standardised warm up package specific to PMAS training based on conventional warm up theories. The study should also recommend when during PMAS training the warm up should be used. All trainers should then use the standardised warm up as recommended.

(ii) Trainers in the PMAS department should receive additional training on conventional theories regarding warm ups. This training should be in depth and delivered by a suitably knowledgeable person. The training should cover areas such as aims and objectives of a warm up, physiological effects of warming up, biomechanical considerations and controversial or contraindicated exercises. This knowledge would then enable trainers to construct safer more effective warm ups.

Injury Recording

The paper records kept by the Public Order Department have provided extremely valuable information for this study. It is recommended that the department continue to keep their own paper records of injuries, in addition to completing the 700B. The Public Order Department have used a number of different forms over the years to record injuries for their own filing system. A new form has been developed as a result of this study. A copy is included at appendix F. The new form has been designed using the best of the forms previously used by the Public Order Department with some additional questions added. It is suggested that the new form is used as it will provide useful accurate information for any future retrospective studies. As indicated by Meeuwise and Love (1997), all injury recording forms have strengths and weaknesses. In designing the new form, an attempt has been made to balance the need for a simple form with the need to obtain sufficient information for future injury studies. Questions have been included in the form that will provide information on internal risk factors as well as external factors. The Public Order Department and Self Defence Department of GMP have recently been merged. In the future, self defence training will take place at one venue and it is anticipated that self defence trainers will be able to use the new form.

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APPENDICES

Appendix A: Copy of Form 700B. The GMP Injury Reporting Form.

Appendix B: Chi Square Analysis.
Injuries GMP.
Injuries Family of Forces.

Appendix C: Chi Square Analysis.
Components of PMAS Training.

Appendix D: Chi Square Analysis.
Mechanisms Causing Injury.

Appendix E: Chi Square Analysis.
Parts of Body Injured.

Appendix F: Suggested Form for Public Order Department to Record Injuries.

Appendix G: Visual representations of the components of training.

APPENDIX A

APPENDIX B

NPar Tests

Chi-Square Test

Frequencies

police force

	Observed N	Expected N	Residual
GMP	97	84.8	12.2
Other forces	168	180.2	-12.2
Total	265		

Test Statistics

	police force
Chi-Square[a]	2.581
df	1
Asymp. Sig.	.108

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 84.8.

APPENDIX C

NPar Tests

Chi-Square Test

Frequencies

tactic/activity

	Observed N	Expected N	Residual
warm up	24	18.5	5.5
vdp	32	12.7	19.3
shield tac	40	80.5	-40.5
enc space	27	41.4	-14.4
tac ex	103	42.3	60.7
combined	9	39.6	-30.6
Total	235		

Test Statistics

	tactic/activity
Chi-Square[a]	167.099
df	5
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 12.7.

APPENDIX D

NPar Tests

Chi-Square Test

Frequencies

mechanism causing injury

	Observed N	Expected N	Residual
missile	95	35.0	60.0
hit other	20	35.0	-15.0
collide stationary object	11	35.0	-24.0
debris	30	35.0	-5.0
fell other	11	35.0	-24.0
sprain/strain	58	35.0	23.0
other	20	35.0	-15.0
Total	245		

Test Statistics

	mechanism causing injury
Chi-Square[a]	164.457
df	6
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 35.0.

APPENDIX E

NPar Tests

Chi-Square Test

Frequencies

part of body injured

	Observed N	Expected N	Residual
foot+ toe	39	42.0	-3.0
leg+ankle	108	42.0	66.0
trunk	32	42.0	-10.0
arm+wrist	42	42.0	.0
hand+finger	32	42.0	-10.0
neck+shoulder	30	42.0	-12.0
head	11	42.0	-31.0
Total	294		

Test Statistics

	part of body injured
Chi-Square[a]	135.000
df	6
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 42.0.

APPENDIX F

# TRAINING INJURY FORM		DATE …………

Injured Officer Details

Pin No…………….. Force …………….. D.O.B. …………… Age ……

Sex ……………. Height ……………. Weight ……………

Officer's perceived level of fitness (scale 1-5). Please delete:

1/ Very Good 2/ Good 3/ Average 4/ Poor 5/ Very Poor

Did officer: Carry on training? ……………………………
Report sick? ……………………………
Go to hospital? ……………………………

Details of Lesson

Level of Training (e.g. PMAS, MoE, Self defence Reclass)
…………………………………………………………………………………………
…………………………………………………………………………………………

Tactic Component of Training (e.g. VDP, warm up, handcuffing palms out)
…………………………………………………………………………………………
…………………………………………………………………………………………

What happened? (Be brief, but precise)
e.g. 1. While running with shield, stood on brick, fell, banged knee on floor.
2. Running during pulse raiser, strained leg, cause unknown.
…………………………………………………………………………………………
…………………………………………………………………………………………

Injury Description (Include part of body)
…………………………………………………………………………………………
…………………………………………………………………………………………

Equipment/Clothing (Is this relevant to injury, if so, how?)
…………………………………………………………………………………………
…………………………………………………………………………………………

Trainer Observations (Comment on factors not covered, which may have contributed to injury)
…………………………………………………………………………………………
…………………………………………………………………………………………

Trainer Pin No. ………….

APPENDIX G

Shield Tactics

Running line then attack from the rear

Shield Tactics

Junctions

Violent Deranged Person

Enclosed Spaces

Building entries

Stairs

Cordons

Petrol Reception