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Published in:
Sport Science Review

Publication date:
2010

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[10.2478/v10237-011-0022-y](https://doi.org/10.2478/v10237-011-0022-y)

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Citation for published version (APA):

Johnson, J., & de Haan , D. (2010). The Influential Games: How the Barcelona Olympics changed the sport of Eventing. *Sport Science Review*, 19(3-4), 133-154. <https://doi.org/10.2478/v10237-011-0022-y>

The Influential Games: How the Barcelona Olympics Changed the Sport of Eventing

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Eventing is a multi-phased equestrian sport consisting of Dressage, Cross-Country, and Showjumping and has been present in the Olympic Games since 1912. The first serious indication of the need for a better scientific understanding of the demands of Eventing was at the 1992 Barcelona Olympic Games. These games saw several horses get into difficulty in the Cross-Country phase, an issue which was extensively broadcast worldwide. Sport specific research increased tremendously following the 1992 Barcelona Games and consequently changes were made to the format of the sport. To date there has been no systematic review of the thematic focus of this research. Therefore the aim of this research was to systematically review literature directly relating to Eventing post 1992.

Systematic review methodology was utilized in this study. Data analysis consisted of meta-synthesis resulting in the identification of areas of thematic relevance including; hydration and thermoregulation, climatic concerns, physiology and performance, travel and risk factors (safety / injury), event management issues and changes to the structure of the sport. This review highlights the wealth of research produced with regards to the sport of Eventing since the 1992 Olympic Games and how this research has influenced the management of this sport.

Keywords: Olympic Games, history of sport, literature review.

Introduction

Equestrian sport has many incarnations around the world which reflect the historical relationship between man and horse. Indeed, the anthro-zoological relationship between man and horse very much dictates where equestrian sport

resides in a socio-historical context (Dumbell, Johnson, & de Haan, 2010). The fact that equestrian sport involves a relationship between the 'human' athlete and the 'horse' as an athlete often subjects the status of the sport to scrutiny when comparisons are made with other sports and their cultural agendas (Merlini, 2004). Most equestrian sport has derived from the need to practice and develop equestrian (riding) skills and several popular equestrian sports, still actively participated in around the world, have developed from a historical military milieu.

Although the type of events and format has changed slightly over the years, equestrian sports effectively made their debut at the summer Olympics in 1900, although they failed to appear in the next two summer Olympics, equestrian sports have been consistently present at the summer Olympics since 1912. The equestrian events chosen for inclusion in the modern Games were European riding disciplines with roots in classical horsemanship, fox hunting and tests of cavalry skills complementing the European Military influence seen elsewhere in the Olympic movement. In preparation for the 1912 Olympics, cavalryman Count Von Rosen came up with the three discipline set-up which is the Olympic equestrian programme still in force today: Eventing (referred to at the time as the Military) Dressage, and Jumping.

Dressage and Jumping events were originally open to none military horses and riders. The sport of Eventing however, had stringent eligibility rules for both the horses and riders with the event originally only open to active duty military officers and their mounts which had to belong to the competitors themselves, or to their respective branch of service (Bryant, 2008). Today Eventing is the equestrian equivalent of the triathlon, incorporating three phases designed to mirror the challenges faced by the cavalry. Cavalry horses had to be all round performers, agile over obstacles and all kinds of terrain, highly responsive and obedient. To test these skills Eventing originally included a none jumping endurance test (road and tracks) a speed test (the individual steeplechase) a cross-country jumping course, a stadium jumping course and dressage test (Bryant, 2008).

Today the equestrian sports represented at the Olympics are open to both male and female competitors but this wasn't always the case. Prior to 1951 only male riders were allowed to compete, however 51 years after the first women competed at the Summer Olympics, the international governing body of equestrian sport, the Federation Equestre Internationale (FEI) decided to allow women to compete in the same competition as men in Dressage but not Eventing or Showjumping. The first female competitor in Eventing was Helena du Pont who rode for the USA at the 1964 Games in Tokyo.

At the 1912 Olympics, the Eventing competition was held over five days and consisted of four aspects of competition: endurance and cross-country on day one, a rest day on day two, the speed test on day three, stadium jumping on day four and dressage on day five. At the Paris Olympics in 1921, the format was changed to include three distinct elements of competition over three days: day one dressage, day two the endurance test which included four phases of competition consisting of Phase A 'road and tracks', Phase B 'steeplechase', Phase C 'cross-country', and Phase D 'road and tracks', the final day of competition was stadium (show) jumping. The 1964 Games in Tokyo saw the addition of the mandatory ten minute halt section between the Phase C and D designed to allow for recovery and for a veterinary checks to be made to ensure horses were fit enough to continue. This format of competition remained the same with no further changes made prior to the Barcelona Games.

Every four years the Olympic Games are hosted by a different city. The global movement and relocation of the Olympics brings unique event management issues for most sports no more so than for equestrian sports. Not only are there issues pertaining to getting horses to the event but once there teams face the challenge of heat, humidity, altitude, pollution, changes to time zones etc which not only affect human athletes but also the horses (Marlin, 2009). The Games of the XVIII Olympiad, held in Japan's capital city, Tokyo, were the first to be held in Asia. In relation to the European dominance in equestrian sport at the Olympics, these were only the second Olympics, after Los Angeles in 1932, for which most horses had to travel across the world. Unlike 1932, when only six nations had been represented, 116 riders from 20 countries competed in Tokyo (FEI, 2009). For the first time in Olympic history horses travelled by aircraft, although as a result three had to be destroyed. The US Eventing horse Markham panicked on departure from Newark airport, Chile lost a Jumping horse on the way to Tokyo after a heart attack, and an Argentinean horse had to be destroyed on the flight home. The Soviets chose not to fly the horses and travelled to Tokyo by sea, although none of the horses were destroyed as a result of the voyage, they were caught in a typhoon.

There have been concerns regarding the inclusion of horses at several games, including quarantine issues relating to Melbourne (1956) which resulted in the equestrian event being held in Stockholm, and Beijing (2008) where the equestrian competition took place in Hong Kong approximately 1225 miles away from the Olympic Stadium (de Haan, 2009), and heat concerns pertaining to the Games in Rome (1960), Los Angeles (1984) and Seoul (1988) (Marlin, 2009). However, as Marlin (2009) reports, the first serious indication of a need for better research relating to the demands of the Olympic equestrian sport,

specifically the sport of Eventing which is seen as the most demanding of the three disciplines, came as a result of the 1992 Barcelona Games.

During the Cross-Country phase at the Barcelona Olympics, several horses exhibited signs of heat distress linked to exercise-associated hyperthermia. Veterinarians working with the horses at the end of this phase reported many horses' temperatures reached the maximum readings on their thermometers of 42C (Marlin, 2009). Competing under these conditions even for short periods is obviously undesirable and many riders reported ongoing problems with their horses even post Games. Initial review of the Eventing competition at the Barcelona Olympics indicated several causal factors which may have contributed to the significant thermal problems reported. Firstly there was the increasing technical and physical difficulty of the course and related jumping elements combined with the lengthy roads and tracks and individual steeplechase section. At the Barcelona Games the challenging Cross-Country phase happened to coincide with multiple environmental issues such as heat, soft going and difficult terrain combined with event management related decisions such as competition scheduling which meant riders were competing in the heat of the day. Secondly in the early 1990s there was a general lack of scientific and clinical research specifically relating to the sport of Eventing. For example whilst we may have been aware of the significance of heat acclimatisation for human athletes we had yet to apply this knowledge to the equine athlete.

Having been shocked by the competition environment and experience in Barcelona, those involved with the sport of Eventing had only four years to prepare for Atlanta which would deliver similar temperatures combined with issues of humidity. In response the FEI, launched a research initiative specifically to provide a clearer understanding of the effects of hot thermal environments on competing horses. In 32 years between 1960 and 1992 there had only been 24 papers published relating to this subject, yet between 1992 and 1996, 23 papers were published followed by a further 28 papers between 1996 and 2000 (Marlin, 2009). There is no doubt that this surge in research has informed how we train, prepare and manage horses in relation to Olympic competition and this body of knowledge has ultimately informed and changed event management and policy issues. However, to date there has been no systematic review of the thematic focus of this research.

Methods of Research Synthesis

Reviewing the literature on a particular topic of interest is an obligatory prelude to almost every researcher's report. Traditional literature reviews are often referred to as 'narrative' reviews and whilst this section of many research reports

will come with the prefix 'critical', these literature reviews have come under criticism with regard to rigour, comprehensiveness and accountability (Tranfield, Denyer, & Smart, 2003). Indeed the focus of the traditional 'narrative' literature review is often left to the researcher's discretion; this section of a research project often serves as a tour around the topic area, including highlights selected by the researcher, providing snapshots of significant issues and signposts to perceived gaps in literature which the current project aims to fill. Dixon-Woods, Booth and Sutton (2007) argue that whilst a traditional narrative literature review provides an overview of the field, they rarely make sense of what the collection of studies reviewed has to say. Indeed Solesbury (2002) criticises research efforts in the social sciences for not fully utilising past research, a problem which Weed (2005) feels maybe due to the use of narrative rather than systematic reviews.

Issues of credibility linked to replicability are not surprisingly grounded in the positivistic sciences. Indeed, within the medical sciences the evidence-based movement has, since the late 1980s, drawn attention to the comparative lack of rigour in secondary research (Mulrow, 1987, 1994). Consequently within this field, over the last 20 years systematic reviews have increasingly replaced traditional narrative reviews as a way of summarising research evidence (Hemmingway, 2009). Whilst research synthesis methods such as the systematic literature reviews are primarily evident in positivistic sciences, Weed (2005) outlines that a number of social sciences are developing an interest in research synthesis as a primary research activity. Whilst systematic reviews have been well documented in the field of medical science, there is a small but growing body of research outside of medicine which is beginning to utilise the more formal systematic review.

The following section outlines the three methodological stages of a systematic literature review as guided by Tranfield et al (2003); planning the review, conducting the review and finally reporting and dissemination, with reference to the current study. The paper then goes on to discuss the application of the research methodology in relation to the sport of Eventing and the influence of the 1992 Olympics on subsequent research and management of the sport.

Stage One of a Systematic Literature Review: Planning the Review

As a prelude to actually beginning the review, a scoping study is carried out. This enables the researchers to assess the relevance and size of the literature from a cross-disciplinary perspective. Within medical science the researcher would arrive at a definitive review question which is central to the process. At this stage of the current study a more flexible approach was warranted, one which would allow for a process of exploration and discovery. However, in order to

avoid drifting into bias associated with narrative reviews, the researchers had to remain focussed on producing a protocol for the subsequent systematic review that would not compromise the integrity of a review.

The scoping study provided a good approximation of the range of literature available and also gave a clear indication of the databases with the highest number of relevant articles and sources. However a wide range of key search terms were identified (Table 1) and sport specific (Eventing) research was difficult to isolate. Having compiled the data and carried out a brief review of the process, it was concluded that a systematic review was both a feasible and beneficial method to capture and analyse all relevant literature.

The first step in the systematic review process is to form a panel of experts with a broad range of knowledge in both the research topic and methodology. For the purpose of this study, the panel consisted of, a library and information scientist and the researchers. The researchers conducted an adapted version of a nominal method, and a brain-storming session was held with each member of the panel. The feedback received helped direct exploration of further field(s) and sub-field(s) within the research area and helped to identify suitable databases to facilitate appropriate searches.

Whilst a systematic review aims for comprehensive coverage of a particular field, the comprehensiveness is set within boundaries to aid identification of relevant studies. In order to aid focus different 'rounds' of searches are conducted, as Weed (2005) outlines, the first round of searches can be overwhelming (often returning over 10,000 articles) and therefore 'exclusion criteria' are established to help filter studies to a more manageable number. These 'filters' or 'exclusion criteria' are determined by the panel of experts and are predetermined prior to commencing the search, to reduce the likelihood of bias during the selection process (Evans & Chang, 2000).

The second fundamental stage of the systematic review process is creating the planned protocol which ensures objectivity on behalf of the researcher as it provides detailed descriptions of the decisions taken along the way (Tranfield et al., 2003). Davies and Crombie (1998) suggest that a review protocol should include; the specific questions addressed by the study, the study focus in terms of population and sample and the search strategy for identification of relevant studies. Those conducting systematic reviews believe the existence of pre-determined protocol reduces the likelihood of bias from the investigator(s) during the selection process (Evans & Chang, 2000). The protocol used for this study is outlined in Figure 1, with further detail presented in Table 1.

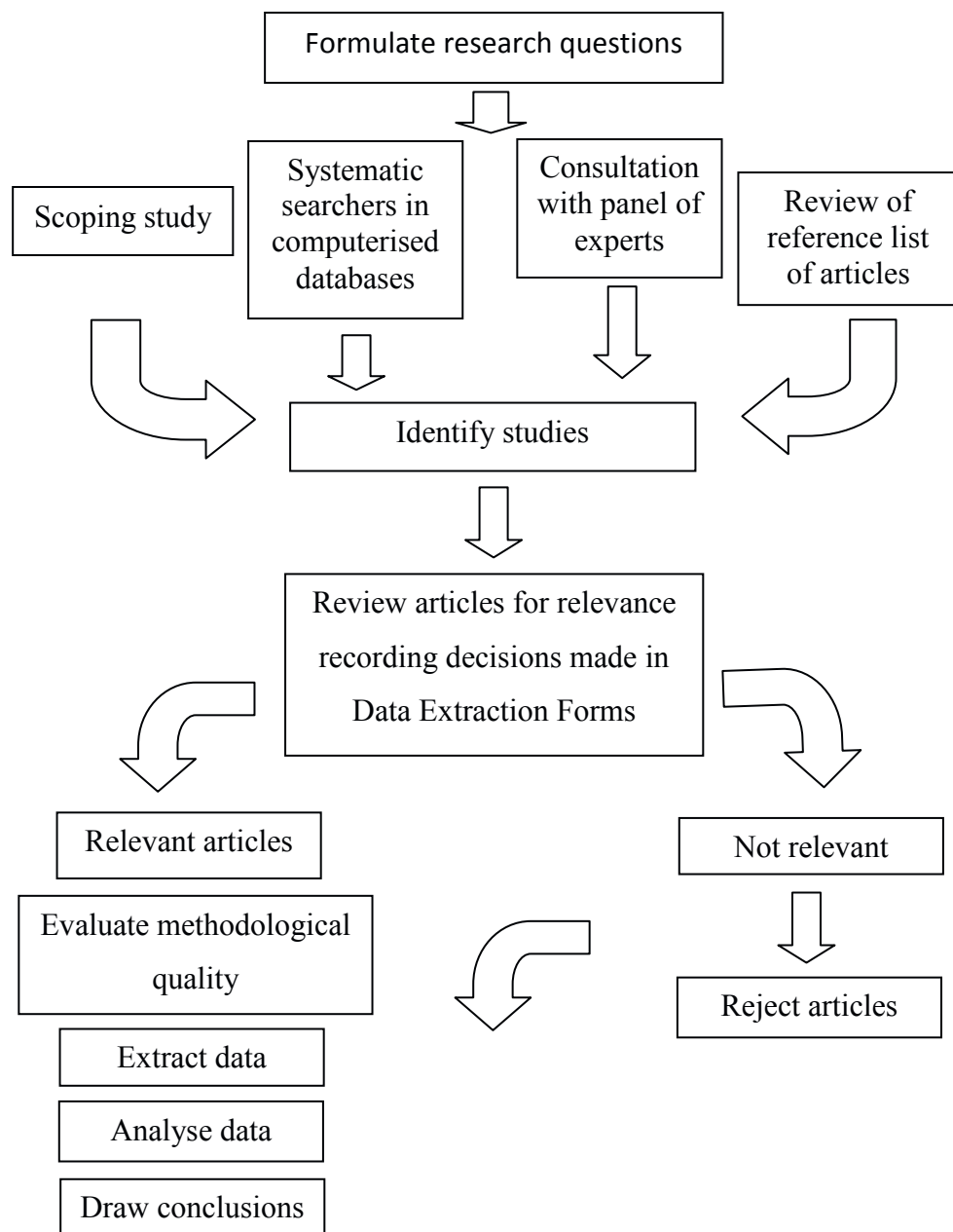


Figure 1. Documenting steps of a systematic review protocol.
Source: Adapted from: Papadopoulos & Rheeder (2000)

Stage Two of a Systematic Literature Review: Conducting the Review

A systematic search starts with the identification of keywords and search terms, identified as a result of the scoping study, the preliminary review of literature and discussions with the review panel (Tranfield et al., 2003). The search strategy has to be reported in enough detail to facilitate repeatability. Within the scoping study the terms 'Horse' and 'Equine' were both used, however 'Equine' did not return any unique studies not sourced using 'Horse'. For the purpose of this particular study, searches using key search terms (Horse used with one of eight combination keywords) were conducted primarily using bibliographic databases (four separate databases identified) (Table 1). The criteria for inclusion and exclusion were discussed between the researchers and information scientist. Defined criteria for inclusion were that papers were written in English, undergone peer review process, were more than three pages in length (thereby disregarding abstracts, conference proceedings, poster etc), and due to the significance of the Barcelona Olympics the reviewers were only interested in papers published post 1992 (Table 1).

Having worked systematically through the databases using the key search terms and the inclusion criteria, details of the resulting studies were recorded in data extraction forms. These forms are intended to reduce human error and negate bias as much as possible and according to Clarke and Oxman (2001) they should contain; general information (title, author, publication details), study features and specific information (details and methods), and notes on emerging themes. At this stage the researchers evaluated the studies and excluded those deemed not relevant to the study. For example the search term 'horse' and 'Olympic' can capture studies relating to gymnastics and the pommel horse.

In medical sciences, the data extraction would result in meta-analysis, an alternative to research synthesis which is conducive to quantitative data. In the social sciences an interpretive or inductive approach is required, the most common being realist synthesis and meta-synthesis. For the purpose of this study a meta-synthesis approach was applied to identify emerging themes.

Stage Three of a Systematic Literature Review: Reporting and Dissemination

Within social science research a two-stage report is usually produced. The first provides a full overview in the form of a 'descriptive analysis' based on the criteria collected and recorded on the extraction forms, the second stage presents 'thematic analysis' (Tranfield et al., 2003). Using an interpretive approach to analyse

the data, the broad themes emerging from the literature are reviewed and documented. For the purpose of this study only descriptive analysis will be presented.

The following Table (Table 1) provides a detailed overview of the individual stages of the review methodology, specifically applicable to this study.

Table 1. A comprehensive overview of the individual stages of the systematic literature review methodology specifically applicable to this study

Stage One: Planning the review	
Scoping study	Defining and clarifying research aims and questions. Descriptive review of literature used to identify key words and help shaped review strategy.
Formation of expert review panel & presentation of review proposal	Review Panel: Donna de Haan (Researcher) Jenni-Louise Johnson (Researcher) Rachel Johnson (Library and information scientist)
Production of review protocol	Discussion, definition and design of search strategy, study selection criteria, data extraction forms.
Stage Two: Conducting the review	
Systematic search of identified sources using identified keywords and search strings	Identified databases: Pubmed; CAB Abstracts; SPORTDiscuss; Science Direct. Meta keywords: Horse + Eventing; Acclimation; Acclimatisation; Thermoregulation; Heat; Humidity; Olympic; Competition
Inclusion or exclusion based on pre determined criteria	Defined criteria for inclusion: 1. Written in English 2. Academic relevance – refereed journals 3. Length – exclude abstracts only or less than three pages 4. Published post 1992
Evaluation of studies and completion of data extraction forms and production of detailed monitoring process	Exclusion based on lack of relevance to this study
Conducting data synthesis	Descriptive analysis
Stage Three: Reporting and dissemination	
Produce report containing descriptive and analysis	Introduction, stages of review methodology, results of key word searches, descriptive analysis and conclusion.
Informing research and practice	Dissemination of systematic review findings and analysis through thesis and publications

The ability to conduct systematic reviews has only been made possible because of access to electronic databases. Following consultation with members of the expert panel to identify appropriate databases and key search terms, a systematic approach to searching the databases was then undertaken (April 2010). Where available, database functionality was used to filter keyword hits based on the pre defined criteria for inclusion (Table 2).

Table 2. Basic search criteria used for each database

Database	Search Criteria (Filters) Used
Pub Med	Language: English Journals Key word search under: 'Abstract' Dates from 1993 to 2010
CAB	Language: English Peer Reviewed Key word search under: 'Abstract' Dates from 1993 to present
Science Direct	Language: English Journals Key word search under: 'Abstract, Title, Keywords' Dates from 1993 to present
Sport Discus	Language: English Peer Reviewed Key word search under: 'select a field (optional)' Length of article could be selected under advanced search Dates from 1993 to 2010

Results

Tables 3-6 show the keyword search results for each of the four databases. Results in each table were divided into three categories 'Original', 'Unique' and 'Relevant'. Under 'Original' were the numbers of keyword hits recorded using pre-defined filters. So for example in the database PubMed, the search terms Horse + Eventing, returned 25 papers written in English, published in refereed

journals, more than three pages long and published post 1992.

Due to the fact that some studies may pertain to more than one keyword search and there may be repetition of studies across the four databases, a hierarchy of repeatability was used to identify repeated studies. A data extraction database was created in Microsoft Excel and the following information (where available) was recorded:

- Database
- Search words
- Author(s)
- Date of Publication
- Title
- Abstract
- Journal

Microsoft Excel has the ability to analyse and manipulate data (for example filter and pivot table functionality) which allowed for identification of repeated and / or duplicated data. To address issues of repeatability, databases and search terms were given a ranked hierarchy (repeatability hierarchy) simply based on order presented. For example, PubMed was the first database searched, therefore if any articles were subsequently identified in any other database they were only included as a 'hit' for PubMed. All search terms were included and the hierarchy, again based on order of search, starting with 'Horse + Eventing' and ending with 'Horse + Competition'. The number of keyword hits recorded under 'Unique' in Tables 3-6, were adjusted figures from 'Original' to account for repeatability.

Finally, the 'Unique' studies were assessed for their relevance to the current study; as identified in the introduction section, this particular study is looking to identify studies relating to training, preparation and management of horses in relation to Olympic competition. For example studies rejected at this stage included research that was not related to equestrian Olympic disciplines such as endurance and reining, and studies not related to equestrianism such as research on parasites and the subject of gymnastics (pommel horse).

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Table 3. Keyword search results PubMed database

		PubMed		
		Meta keyword: Horse		
		Original	Unique	Relevant
A	Eventing	25	25	14
B	Acclimation	41	41	19
C	Acclimatisation	35	4	3
D	Thermoregulation	102	93	53
E	Heat	474	419	23
F	Humidity	99	51	2
G	Olympic	30	21	2
H	Competition	254	237	26
Total		1060	891	142

Table 4. Keyword search results CAB database

		CAB		
		Meta keyword: Horse		
		Original	Unique	Relevant
A	Eventing	30	30	13
B	Acclimation	22	20	4
C	Acclimatisation	4	4	0
D	Thermoregulation	46	44	13
E	Heat	289	247	2
F	Humidity	87	71	2
G	Olympic	25	25	4
H	Competition	252	250	8
Total		755	691	46

Table 5. Keyword search results Science Direct database

		Science Direct		
		Meta keyword: Horse		
		Original	Unique	Relevant
A	Eventing	10	10	4
B	Acclimation	8	8	1
C	Acclimatisation	4	4	0
D	Thermoregulation	12	12	5
E	Heat	133	128	7
F	Humidity	22	13	0
G	Olympic	10	7	1
H	Competition	112	100	4
Total		311	282	22

Table 6. Keyword search results Sport Discus database

		Sport Discus		
		Meta keyword: Horse		
		Original	Unique	Relevant
A	Eventing	5	4	3
B	Acclimation	4	1	0
C	Acclimatisation	4	2	0
D	Thermoregulation	4	2	0
E	Heat	12	8	0
F	Humidity	2	0	0
G	Olympic	24	16	2
H	Competition	47	16	2
Total		102	49	7

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In total 217 unique relevant studies were identified, with papers published in every year from 1993-2010 (Table 7). During 1995 and 1996, 27% of the total number of relevant papers were published, with a further increase in publication output during 1999. In relation to this, the data extraction database highlighted that there were certain groups of researchers. Analysis of author output revealed that there were 87 (40%) publications produced with four or more authors. Of these 87 papers, research output mirrored the trend as previously identified above with the group research also being noticeably higher in 1995, 1996 and 1999 (21%, 13%, 10% respectively).

Table 7: Number of relevant studies published per year.

Year	Number Published
1993	12
1994	11
1995	29
1996	29
1997	10
1998	16
1999	22
2000	7
2001	8
2002	12
2003	2
2004	7
2005	15
2006	10
2007	5
2008	14
2009	6
2010	2

Descriptive Analysis. The final part of ‘Stage Two’ of the systematic review is conducting the data synthesis, which for the purpose of this study involved reviewing the relevant identified 217 articles using descriptive analysis to produce first order themes. Eleven first order themes were identified (Table 8).

Table 8. Identified first order themes

	Theme	Number
1	Hydration and Thermoregulation	66
2	Climatic Concerns	48
3	Physiology	40
4	Performance	20
5	Codification	10
6	Transport	7
7	Safety	7
8	Horse Injury	6
9	Management	5
10	Rider	5
11	Welfare	3

Further analysis of the eleven first order themes in relation to year of publication (grouped by decade), identified certain trends in research output (Figure 2).

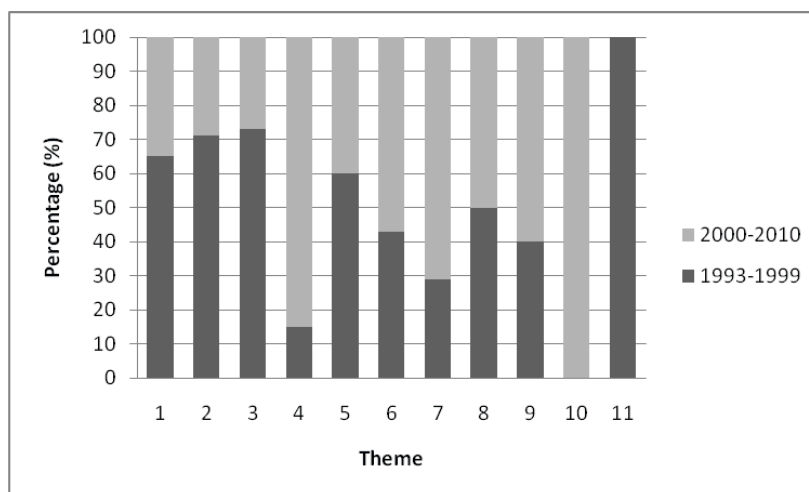


Figure 2. Total % of research output in relation to theme and publication date

In relation to the first three themes, 'Hydration and Thermoregulation', 'Climatic Concerns', and 'Physiology', it is apparent that the majority of the research output occurred between 1993 and 1999 (65%, 71%, 73% respectively). However, 'Rider', 'Performance', 'Safety', and 'Management' all produced a greater amount of research between 2000-2010 (100%, 85%, 71%, 60% respectively). The theme 'Codification' also produced a higher percentage research output (60%) in the 1990s, with 67% of this occurring during 1995-1996.

Discussion

Outside the context of the Olympics, Eventing originally evolved in Europe with a competition season running through autumn and spring. Today however, the competition season (in the Northern hemisphere) runs from spring to autumn and the international nature of the sport means that competitions are often held in various climatic conditions. Whilst climatic conditions will be taken into account when planning and organising equine specific events, these considerations are not afforded to the sport specifically in the Olympic context. With respect to this, the first major concern for equestrian events at the Olympics was Barcelona in 1992. Whilst there is a plethora of research pertaining to human athletes physiological responses to extreme climates which help prepare athletes for training and competition, this same type of research was not available to those managing the equine athlete. In 1992, Spain's extreme heat challenged horses competing in Barcelona. The heat stress not only dampened overall performance but the TV coverage of the Games highlighted horses in difficulty during the actual competition. The apparent distress to horses and resulting performance in Barcelona combined with the fact that the next Olympics were to be held in Atlanta, a climate with higher heat and humidity than Barcelona, resulted in the equine industry indentifying the need to research the equine as an athlete in the same way as the human athlete. Sport specific research therefore increased tremendously following the 1992 Barcelona games and consequently changes were made to the format of the sport. To date there has been no systematic review of the thematic focus of this research. Therefore the aim of this study was to systematically review literature directly relating to Eventing post 1992.

In order to fully analyse the range of research produced post 1992, a systematic literature review methodology was adopted to avoid researchers' bias, which is often a consequence of a traditional 'narrative' literature review. The systematic literature review methodology used in this study utilised four separate databases and one Meta keyword combined with eight individual search terms and identified 217 unique, relevant papers. Whilst results indicated that papers were published every year from 1993 to the present day, it was apparent that 27% of the total number of papers were published in 1995 and 1996 and 40% of the

total number of papers were published by groups of four or more researchers. These results can be explained by the international research programme that was set up in response to the Barcelona Games in preparation for Atlanta 1996. Groups based at research facilities around the world launched several studies shortly after the Barcelona Olympics to determine the best ways to develop heat tolerance in equine athletes through training, acclimation and nutrition (for example, Marlin et al., 1995; Lindinger, Geor, Ecker, & McCutcheon, 1995). Prior to this verified methods of managing horses tolerance to hot and humid conditions had not been established. The researchers found that horses respond to the same type of acclimation program as practiced in human athletes, which consists of gradual exposure to heat and humidity (Lindinger, 1999).

Descriptive analysis of the literature identified eleven distinct themes, with the first four themes ('Hydration and Thermoregulation', 'Climatic Concerns', 'Physiology' and 'Performance') accounting for a far greater researcher output. In relation to the first three themes, it was apparent that the majority of the research was published between 1993 and 1999 with the first peaks seen in 1995 and 1996. Review of the papers taking into consideration both theme and publication date identified two significant supplement publications by the Equine Veterinary Journal, which specifically concentrated on research pertaining to lessons learnt from Barcelona and preparation for the Atlanta 1996 Olympic Games. The first of these publications, 'Progress towards Atlanta 1' published in 1995, provided a platform for research results, highlighting the effects of performance and well being of horses working in hot climates. The second publication 'Progress towards Atlanta 2' published in 1996, was a continuation of research, highlighting the prominence of surrounding environments on the training of horses including; weather monitoring, thermal balance and nutritional strategies.

The results also highlighted a further peak in research output during 1999. Analysis of these papers indicated similar themes as identified in 1995 and 1996, again representing the first three themes. It was also noted that of the 22 papers published in 1999, 55% were published in an Equine Veterinary Journal supplement entitled, 'Equine Exercise Physiology 5'. It is therefore apparent that the identified peaks in publication output during the 1990s are all related to one specific publication and associated supplements. This again reflects the collaborative cohesive approach to this international research programme and dissemination. This type of controlled research and propagation of findings from an international perspective had not been seen previously or indeed since.

Whilst the descriptive analysis of the papers identified eleven themes, the parameter of these themes is not always definitive. Due to the dearth of research investigating physiological responses of the equine athlete prior to

1992, methodology was adapted from the human sport sciences resulting in the same interdisciplinary approach to equine research. The very nature of the interdisciplinary methodology means that distinct themes are not translucent, therefore strict and consistent criteria was used to categories papers. The first three themes for example are closely linked to environmental influence on performance and all themes can ultimately relate to performance and welfare.

Based on the experiences in Barcelona and the findings from the international research programme, aspects of the sport of Eventing were adapted to cope with the hot and humid summer conditions in Atlanta. Although Eventing consists of three stages of competition over three days, research proved that the most severe stage was the endurance phase, especially when it was held under conditions of extreme heat and humidity (White, Williamson, Maykuth, Cole, & Andrews, 1995). Therefore in order to minimise adverse effects to performance during this stage of competition, modifications were made to the speed and endurance phase, including early morning starts that finished by late morning, an additional ten minute mandatory halt to allow for cooling between Phases A and B, a reduced distance for the roads and tracks in Phase D, and the ten minute box between phases C and D was extended (Marlin, 2007). Rapid cooling techniques were also introduced during the rest-pause and recovery periods in Atlanta as these were found to be important to facilitate heat dissipation in the horse (Kohn & Hinchcliff, 1995). These adaptations were deemed to be successful as unlike in Barcelona; there were no cases of heat exhaustion / heat stroke, anhidrosis or rhabdomyolysis reported in Atlanta. These changes subsequently remained at the next Olympics in Sydney.

In 2002 it was reported that the IOC proposed further changes to the format of Eventing based on recommendations put forward by the FEI. The IOC announced a move to implement a new reduced format for Eventing to be implemented at the 2004 Olympics in Athens. It is important to note however that this proposed change was not a direct reflection of Barcelona and Atlanta or the associated research; rather the changes were driven by the IOC's objection to the cost of hosting Eventing within the context of the Olympics. The IOC objected to the original long format on the grounds that the event was too expensive to run and host nations were often left with unwanted facilities, issues pertaining to the safety of the sport were also of concern (Gee, 2002). The proposed modifications were put into place and the first short format of Eventing was seen at the Athens Olympics in 2004 although this new format was not implemented at the four star international competitions of Kentucky, Badminton or Burghley until the 2006 season. Whilst the findings of the post 1992 research were not used to justify the changes to the format, it is interesting to note that the short format resulted in the removal of Phases A, B and D

which was previously identified as the most challenging aspects of the sport in relation to conditions of extreme heat and humidity.

In relation to the changes in format, the results of this study show an increase in research output relating to the themes of safety, management and performance during 2000-2010 compared to the 1993-1999. Although safety was highlighted as a reason for changing the format, there are still ongoing concerns relating to the safety of both horses and riders with respect to the cross-country phase as the change in format did not reduce the number of fatalities. It is also interesting to note that of the 217 identified papers, only five specifically focus on rider based research and 100% of these were published post 1999. Anecdotal evidence from lay-press and strategies produced by the relevant sport governing bodies, would suggest that there is a small but new emergent interest in rider focussed research.

The effect of the climate on performance at the Barcelona Olympics and subsequent preparation for the Atlanta Olympics resulted in an international research focus which produced a timely plethora of research and change to the structure of the sport. The legacy of this research and change to the management of the sport is still apparent today. This is reflected in the format of the sport and in relation to methodologies and results used to inform more recent studies and preparation for the Beijing Olympics (Jeffcott, Wing-Mo & Riggs, 2009).

Conclusion

Prior to the Barcelona Olympics in 1992, management of horses in a competition environment had not been affected by climatic conditions adversely effecting performance. Concerns raised as a result of the Barcelona Olympics relating to the performance and welfare of horses in hot climates, resulted in the development and implementation of an international research programme, which subsequently produced an abundance of papers on this topic. To date there has not been a review of this research in relation to theme and implications. Using a systematic literature review methodology, this paper can conclude that the cohesive, collaborative international research initiative launched post 1992, did produce a significant research output on a specific topic area, the likes of which had not been seen previously or since.

Research included in these studies, adapted methodologies from the human sport sciences, indicating consideration of the horse as an athlete. Indeed analysis of this particular research project focuses on the equine rather than the rider, in a sport which combines the physiological performance of both. The Barcelona Olympics not only influenced the development of a global research

initiative, but the results of this research lead to a change in the format and management of the sport, the legacy of which can still be seen today. Reflections on the lessons learnt from the Barcelona Olympics, and the subsequent impact on research and management of the sport, indicates that a similar responsive approach to a cohesive research project, could be implemented to successfully address contemporary issues facing the sport today.

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