1 History of Equine Exercise Physiology

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Horses were domesticated by humans 5500 years ago and have been used in agriculture, warfare, and sport since that time (Chapter 2).[1,2] Horses, with some selective breeding, were ideally suited to these pursuits, but it was not until the early to mid-twentieth century that science began to investigate the basis for the remarkable athletic capacity of horses. The history of equine exercise physiology has been well reviewed by McKeever and will not be repeated in detail here.[3] Instead, we will focus on the formative contribution of a series of conferences, and in particular the International Conference on Equine Exercise Physiology (ICEEP), to the science of equine exercise physiology.

Because the very nature of the scientific process is one of checks and balances, progress in the generation and dissemination of new evidence-based information is incremental and comparatively slow. Periodically, increases in the rate at which new information is produced is facilitated by a combination of the need for this information, technological innovation, its application to a particular scientific discipline, and opportunities for scientists to convene, present, and discuss cutting edge research. This was the case with respect to equine exercise science in the 1960s, when there was a paradigm shift from examining horses before and after exercise or during relatively low-intensity exercise on slow treadmills, to use of emerging technologies to examine horses running at high speed on a treadmill. What was missing were opportunities for scientists to gather and discuss their studies, and this changed in the 1970s with increasing ease of international travel, recognition of the importance and value of input from across the globe and funding to support such meetings.

Modern Equine Exercise Physiology

"Modern" equine exercise science is generally regarded to date from the use of the first high-speed equine treadmill and use of advanced technologies including indirect calorimetry, electrocardiology and muscle biopsy. The first high-speed treadmill was custom built in Stockholm for the Department of Medicine I in the Royal Veterinary College, Stockholm in the 1960s. The availability of this treadmill, which had a maximum speed of approximately 11 m/s, led to the seminal doctoral thesis of Sune Persson (Fig. 1.1).[4] Persson investigated the previously documented observations that the hematocrit of horses could increase by up to 50% during exercise and that the magnitude of this increase was related to workload and eliminated by splenectomy.[5,6]

The manufacture of this treadmill enabled controlled exercise studies in terms of speed and environmental conditions. For the first time it was possible to perform reproducible exercise tests for basic physiological studies of horses' responses to exercise and to apply these understandings to the clinical evaluation of horses demonstrating a reduced exercise capacity. Persson's doctoral thesis work was followed by further studies, perhaps the most important of which investigated the effects of splenectomy on equine performance and reinforced the role of splenic contraction on exercise-induced changes in a number of hematological and cardiovascular variables.[7–9] One of Persson's collaborators in this work was Gunnar Bergsten, who was Persson's doctoral student and followed up his mentor's work with the first study of the effects of exercise at moderate speed on cardiac output, blood gases and blood

• **Fig. 1.1** Sune Persson at ICEEP 7. (Courtesy E. Barrey.)

pressure.[10] However, not all groundbreaking studies involved use of the high-speed treadmill.

At about the time Bergsten was pursuing his PhD, another young member of the Swedish Royal Veterinary College was doing his doctoral studies under the mentorship of internationally renowned exercise physiologist Bengt Saltin. Arne Lindholm adapted technical advances in skeletal muscle biopsy and fiber typing methodology to perform the first studies of equine skeletal muscle fiber types and muscle metabolic responses, including glycogen utilization and lactate concentrations during different exercise intensities in trotting horses.[11–13] These investigations were not conducted on the veterinary college treadmill but rather in the field and paved the way for multiple field and treadmill-based studies of the responses and adaptations of horses to various forms of exercise and training.

An equally important field study was conducted about a decade prior to those of Lindholm et al. Because of its location and the language in which it was reported (Russian), it took some time to gain awareness. Nevertheless, it was noteworthy for its conclusions and the subsequent studies that it stimulated. Two Russians, G. G. Karlsen and E. A. Nadaljak, trotted Soviet heavy breed horses at speeds up to nearly 700 m/min in front of a sulky while a truck drove alongside.[14] The horses wore a mask from which tubes ran to recording equipment in the back of the truck. From these recordings, they generated measurements of tidal volume, minute ventilation, respiratory frequency, oxygen consumption ($\dot{V}O_2$), and carbon dioxide production ($\dot{V}CO_2$) that have proven remarkably accurate based on results of many subsequent studies. However, Karlsen's and Nadaljak's most notable finding at the time was that the exercising $\dot{V}O_2$ increased by more than 35-fold over resting values in these horses. This was about double the magnitude of the increase reported in humans and prompted the question of how these horses' oxygen transport systems adapted to exercise to facilitate such an increase in $\dot{V}O_2$. Efforts to answer this question gave rise to the modern study of horses' cardiovascular responses to exercise.

Investigations of the cardiovascular responses to exercise, conditioning, and influence on performance were conducted during the late 1950s and 1960s by a number of research groups. The first group to delve into this issue was probably that led by von Engelhardt, Ehrlein and Hörnicke at the University of Hohenheim, just south of Stuttgart, Germany, where, with their various students and colleagues, they conducted an extensive series of studies from 1970 to 1977.[15–20] They focused on heart rate, blood pressure, and ventilatory responses to exercise of varying intensities and made extensive use of telemetry to generate their findings, which were summarized in an excellent review by von Engelhardt in 1977.[21] Others investigating the nature of the heart of athletic horses included Steel's group in Australia, which focused on defining the electrocardiogram of horses and its association with exercise and performance.[22–25]

Elsewhere in the world, other groups or individuals who would make important long-term contributions to equine exercise science were emerging. In the United States, a group at Ohio State University led by Dennis Milne and Albert Gabel published a number of studies from 1974 to 1977 detailing the effects of various intensities of exercise on serum biochemistry.[26–30] Meanwhile, at the University of California, Davis, Gary Carlson and Jerry Gillespie were conducting a series of studies of the effects of endurance exercise on respiratory function, body fluid compartment volumes, electrolyte balance and sweat composition, and thermoregulation.[31–33] While endurance racing was growing rapidly in popularity worldwide and other studies of the physiological responses of horses were being conducted elsewhere—notably in Australia and in Glasgow, Scotland—the body of Carlson's work laid the groundwork for many future studies dealing with fluid and electrolyte balance and thermoregulation associated with all forms of equine exercise.[34–37]

All this new and exciting work was happening all over the world, but there was not a venue where these young and emerging veterinarians and equine exercise scientists could gather to present their work for the review and critique of others. An unlikely, to some, opportunity arose in 1974 with the convening of what was advertised as the "First International Equine Veterinary Conference" in Kruger National Park, South Africa. The conference convener was Maurice Azzie, a well-published and influential equine

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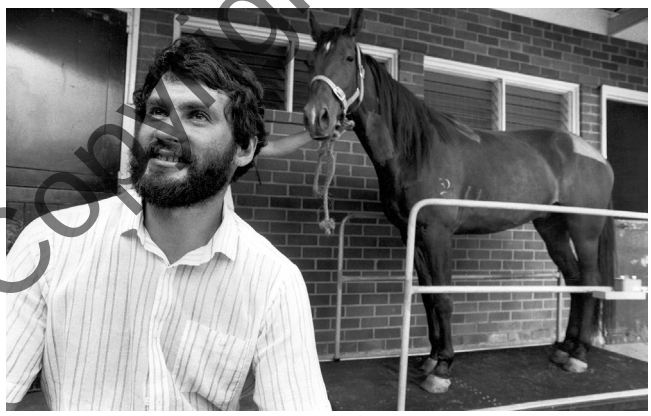
practitioner from Johannesburg.[38] The conference program was focused on equine performance and had presentations on cardiology, hematology, the respiratory system, genetics, biochemistry and electrolytes, all in relation to the effects of exercise on them and their relationship to performance. Speakers presented 16 papers and came from 8 countries.[13,25,26,39–56] The list of participants and authors included a veritable who's who of those scientists who were pioneers in the field of equine exercise physiology.[57] Although it might not have truly been the first international equine veterinary conference, it was certainly the first that was devoted to equine exercise physiology and in many ways was the forerunner to what would become the quadrennial ICEEP. A number of the original leaders of ICEEP attended the South African conference in 1974.

International Conference on Equine Exercise Physiology

The Birth of ICEEP

The first ICEEP was the brainchild of David Snow, who, with assistance of Sune Persson, Gary Carlson, Tom Tobin, and Reuben Rose, organized and convened the conference. David Snow (Fig. 1.2) and Reuben Rose graduated a couple of years apart in the early 1970s from the University of Sydney Faculty of veterinary science. Soon after graduation, Snow took a position in the Department of Veterinary Pharmacology at the University of Glasgow while Rose remained in Australasia and, after a brief period in practice, took a position at the University of Sydney. Each independently began to work on responses of horses to prolonged submaximal exercise.[58,59] Snow was particularly prolific in his research and publication efforts and had clearly established himself as one of the world's leading contemporary equine exercise scientists by 1980.[60–62] Around this time, he conceived plans to organize an international conference focused on equine exercise physiology. He and Rose had connected because of their mutual interest in endurance exercise and, while collaborating on a study and writing the associated paper,[63] began to discuss Snow's plans to hold an international conference on equine exercise physiology. Snow chose Exeter College at Oxford University because of the ambience associated with that venerable university and Exeter being the college at which Roger Bannister was a member while studying medicine and setting the first sub–4-minute time for running a mile. Bannister, who opened the conference, was a fellow at Exeter College. And so ICEEP was born.



• **Fig. 1.2** David Snow. (Image provided by David Snow.)

Organization and Governance

The purpose of ICEEP is to facilitate worldwide understanding of advances in scientific knowledge of the physiology, function, and health of athletic horses by bringing together the world's best researchers and experts in equine exercise physiology and sports medicine. The conference is now held once every 4 years and is convened by the International Committee and locally organized by a National Committee (Table 1.1). The International Committee adopted a constitution, by-laws and articles of incorporation in 1986, and these have been periodically revised and adapted. ICEEP is currently incorporated as a nonprofit organization in the State of Washington, United States of America, on June 4, 2012. The articles of incorporation, constitution and by-laws govern and direct how ICEEP operates and the manner in which the conferences are organized.

The International Committee of ICEEP is responsible for selecting the site of each quadrennial conference and for overseeing the organization of these international conferences by assisting the National Organizing Committee, which is largely composed of members from the host country. The Chair of the National Organizing Committee is typically a member of the International Committee or becomes a member of the International Committee at the next ICEEP. The National Organizing Committee and the International Committee work together to finalize the site, accommodation, budget, and sponsorship of the upcoming ICEEP. The International Committee is responsible for determining the conference's scientific program.

Membership in the International Committee is by invitation and is designed to ensure a broad representation of expertise, geographic location and standing in the equine exercise community. Members of the International Committee are appointed on a rotating basis for terms of no more than three conferences (12 years) so that, for example, the term of someone appointed at the 2002 conference ended at the 2014 conference. The Chair of the International Committee is elected by the members of that committee for one term (4 years). The Chair of the National Committee is appointed by the International Committee based on the location of the next conference and their expertise and ability to oversee local organization of the conference.

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TABLE 1.1 **Details of ICEEP From 1982 to 2022, Including Site, Year, International and National Committee Membership, Major Sponsors, and Publication**

	ICEEP 1982	ICEEP 2 1986	ICEEP 3 1990	ICEEP 4 1994	ICEEP 5 1998	ICEEP 6 2002	ICEEP 7 2006	ICEEP 8 2010	ICEEP 9 2014	ICEEP 10 2018	ICEEP 11 2022
Site	Oxford, UK	San Diego, USA	Uppsala, Sweden	Kooralbyn, Australia	Utsunomiya, Japan	Lexington, Kentucky, USA	Fontainebleu, France	Spier Wine Farm, Stellenbosch, South Africa	Chester, UK	Lorne, Australia	Uppsala, Sweden
Participants	150	80		180		181	250	132	205	278	338
International Committee	D. H. Snow (Chair) S. G. B. Persson R. J. Rose G. P. Carlson J. R. Gillespie T. Tobin	G. P. Carlson J. R. Gillespie H. Hornicke S. G. B. Persson R. J. Rose D. H. Snow	S. G. B. Persson (Chair) G. P. Carlson J. R. Gillespie H. Hoppeler N. E. Robinson R. J. Rose D. H. Snow	R. J. Rose (Chair) G. P. Carlson J. R. Gillespie H. Hoppeler L. B. Jeffcott S. G. B. Persson D. H. Snow	L. B. Jeffcott (Chair) J. R. Gillespie D. R. Hodgson P. Lekeux S. G. B Persson R. J. Rose M. Tokuriki	H. F. Hintz (Chair) E. Barrey W. M. Bayly B. Essen-Gustavsson K. W. Hinchcliff D. R. Hodgson L. B. Jeffcott P. M. Lekeux M. Tokuriki	B. Essen-Gustavsson (Chair) E. Barrey W. M. Bayly K. W. Hinchcliff D. R. Hodgson P. M. Lekeux D. J. Marlin J. D. Pagan M. Tokuriki	D. J. Marlin (chair) E. Barrey W. M. Bayly K. W. Hinchcliff A. Hiraga J. D. Pagan C. McGowan	K. W. Hinchcliff (Chair) E. van Erck A. Hiraga D. J. Marlin E. McKenzie C. McGowan J. D. Pagan R. van Weeren W. M. Bayly (Ex-officio Treasurer)	R. van Weeren (Chair) J. Foreman S. Franklin A. Jansson C. McGowan K. McKeever E. McKenzie E. van Erck W. M. Bayly (Ex-officio Treasurer)	E. McKenzie (Chair) J. Foreman S. Franklin A. Jansson K. McKeever E. van Erck T. Takahashi R. Leguillette W. M. Bayly (Ex-officio Treasurer)
National Committee	Not formed	J. R. Gillespie (Chair) R. M. Arthur G. P Carlson J. R. Coffman M. Cohen A. A. Gabel B. D. Grant H. Hintz M. Mackay-Smith N. E. Robinson J. Smith	A. Lindholm (Chair) G. Dalin S. Drevmo B. Essen-Gustavsson P. Forssberg P. Kallings S. Persson	J. Thornton (Chair) D. Auer D. Lovell B. Mason J. McCaffrey C. Pollitt R. Rose P. Symons D. Wright	M. Tokuriki (Chair) S. Motoyoshi O. Aoki A. Amada S. Arantani M. Oikawa H. Omi I. Otake M. Kai K. Kubo T. Kumamomido H. Kurita S. Sugano T. Senta J. Nakjima Y. Hayashi S. Watanabe	K. W. Hinchcliff (Chair) W. M. Bayly R. J. Coleman J. H. Foreman R. J. Geor J. R. Gillespie L. M. Lawrence J. G. Lengel L. J. McCutcheon J. D. Pagan H. C. Scott	E. Barrey (Chair) S. Biau V. Billat I. Bersinger A. Couroucé-Malblanc B. Langlois C. Robert M. Sloet van Oldruitenborgh-Oosterbaan J. P. Valette M. Weishaupt	T. Casey (Chair) A. Guthrie D. Mullins R. Gottschalk B. vander Merwe M. Schulman M. Ross D. Marlin M. Schultheiss	C. McGowan (Chair) J. Birch P. Harris S. McKane C. Proudman E. Singer L. Young	S. Franklin B. Ahern G. Forbes K. W. Hinchcliff B. Tennent-Brown L. Verdegaal C. Whitton	A. Jansson (Chair) E. Hernlund S. Ringmark M. Rhodin L. Roepstorff K. Dahlborn A. Bergh
Major Sponsors	Horserace Betting Levy Board The Jockey Club The Royal Hong Kong Jockey Club The Irish Turf Club Prince K Abdulla Warner-Lambert Animal Health National	Oak Tree Racing Association Jockey Club-USA American Association of Equine Practitioners Association for Equine Sports Medicine	Swedish Trotting Association Oak Tree Racing Association Boehringer Ingelheim Novo Nordisk Pherrovet Kagrla AG Handelsgesellschaft Steipner Djurforsakringar Pripps Bryggerier AB Innovativ Vision AB	Queensland Department of Tourism, Sport and Racing. The Australian Conference of Principal Racing Clubs. Australian Equine Veterinary Association	Japan Racing Association (JRA) Japanese Society for Equine Science Royal Hong Kong Jockey Club Oak Tree Racing Association	USA Equestrian Kentucky Equine Research Oak Tree Racing Foundation United States Department of Agriculture	Institute of National Research in Agriculture (INRA) Town of Fontainebleu	Purina Mills Horse Business Group Kentucky Equine Research Flair Equine Nasal Strips Japan Racing Association Waltham Science Supplements	Kentucky Equine Research Waltham	Racing Victoria Waltham Kentucky Equine Research	

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	Trainers Federation Publication of the Proceedings was assisted by support from the Animal Health Trust			Oak Tree Racing Association Royal Hong Kong Jockey Club Waltham Centre for Equine Nutrition and Care				5th European Equine Health and Nutrition Congress		
Publication	Equine Exercise Physiology.[1] Eds. D. H. Snow S. G. B. Persson Granta Editions, Cambridge 1983	Equine Exercise Physiology 2.[2] Eds. J. R. Gillespie and N. E. Robinson ICEEP Publications 1987	Equine Exercise Physiology 3.[3] Eds. S. G. B. Persson, L. B. Jeffcott, A. Lindholm ICEEP Publications 1991	Equine Exercise Physiology 4.[4] Ed. N. E. Robinson EVJ Supplement 18 1995	Equine Exercise Physiology 5.[5] Ed. L. B. Jeffcott EVJ Supplement 30 1999	Proceedings of the Sixth International Conference on Equine Exercise Physiology.[6] Eds. K. W. Hinchcliff, R. J. Geor, J. D. Pagan EVJ Supplement 34 2002	Proceedings of the Seventh International Conference on Equine Exercise Physiology.[7] Eds. B. Essen-Gustavsson, E. Barrey, P. M. Lekeux, D. J. Marlin EVJ Supplement 36 2006	Proceedings of the 8th International Conference on Equine Exercise Physiology.[8] Eds. D. J. Marlin and P. A. Harris EVJ Supplement 38 2010	Proceedings of abstracts only. Published online.[9]	Proceedings of abstracts only. Published online.[10]

EVJ, Equine Veterinary Journal; *ICEEP,* International Conference on Equine Exercise Physiology.

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[1]Equine Exercise Physiology. Proceedings of the first international conference. In: Snow DH, Persson SGB, Rose RJ, eds. *International Conference on Equine Exercise Physiology*. Oxford: Granta Editions, Cambridge; 1983:543.

[2]Equine Exercise Physiology 2. Proceedings of the second international conference on equine exercise physiology. In: Gillespie JR, Robinson NE, eds. *International Conference on Equine Exercise Physiology 2*: ICEEP Publications; 1986:580.

[3]Equine Exercise Physiology 3. Proceedings of the Third International Conference on Equine Exercise Physiology, Uppsala, Sweden, July 15–19, 1990. In: Persson S, Jeffcott LB, Lindholm A, eds. *International Conference on Equine Exercise Physiology 3*. Uppsala, Sweden: ICEEP Publications: Distributed by ICEEP Publications, c/o Swedish Racing Association (ATG), Stockholm, Sweden; 1991:508.

[4]Equine Exercise Physiology 4. Proceedings of the 4th International Conference on Equine Exercise Physiology. In: Robinson NE, ed. *Equine Veterinary Journal Supplement 18*. Newmarket: R & W Publications; 1995;479.

[5]Equine Exercise Physiology 5. Proceedings of the Fifth International Conference on Equine Exercise Physiology. In: Jeffcott LB, ed. *Equine Veterinary Journal Supplement 30*. Newmarket: Equine Veterinary Journal Limited; 1999:656.

[6]Proceedings of the Sixth International Conference on Equine Exercise Physiology. In: Hinchcliff KW, Geor RJ, Pagan JD, eds. *Equine Veterinary Journal Supplement 34*. Newmarket, UK: Equine Veterinary Journal Limited; 2002:581.

[7]Proceedings of the Seventh International Conference on Equine Exercise Physiology. In: Essen-Gustavsson B, Barrey E, Leukeux P, et al., eds. *Equine Veterinary Journal Supplement 36*. Newmarket, UK: Equine Veterinary Journal Limited; 2006:671.

[8]Proceedings of the 8th International Conference on Equine Exercise Physiology. In: Marlin D, Harris P, eds. *Equine Veterinary Journal Supplement 38*. Chichester, West Sussex: Wiley-Backwell; 2010:702.

[9]Abstracts from the 9th International Conference on Equine Exercise Physiology, 15–20 June, 2014 Chester, UK. *Equine Vet J*. 2014;46 Supplement S46:1–55.

[10]10th International Conference on Equine Exercise Physiology. *Comparative Exercise Physiol*. 2018;14(Supplement 1):S1-S114.

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The scientific integrity of the conference is of paramount importance and is ensured by the oversight of the International Committee and editors of the proceedings. A call for abstracts is made by the International Committee or its delegated Program Committee in the year preceding the conference. Abstracts are then reviewed by members of these committees and co-opted experts to determine which abstracts are selected for presentation at the conference and, for ICEEPs 1 to 8, for publication as a full-length scientific manuscript in the proceedings (see later). Material may be selected for podium presentations or as a poster. Podium presentations are typically of 12 minutes' duration with 3 minutes allocated to question and answers. At recent conferences, authors providing a poster are invited to make a 3-minute podium presentation.

The structure of the conference has always focused on assembling (in a pleasant venue for 4 to 5 days) the world's leading scientists and the emerging ones interested in exercise physiology of the horse. Beginning with ICEEP 4, the conferences consisted of 4 days of presentations separated by a rest day when participants enjoyed various extracurricular activities. Conferences 3 to 6 included workshop or panel discussions on selected topics. Each ICEEP has a social program that encourages interaction and discussion in various relaxed informal and formal events.

Publication and Proceedings

For ICEEPs 1 to 8, proceedings were published that included peer-reviewed articles of studies presented at the conference. These proceedings continue to be an invaluable resource for researchers and at the time were a veritable compendium of articles describing state of the art developments in equine exercise physiology. They now serve as important historical records of the early days of equine exercise physiology, recording not only sentinel studies but also the names of those scientists and veterinarians who were active at the time. Students of equine exercise physiology should be familiar with the articles in these proceedings so as to avoid repeating earlier, excellent work. The proceedings of the first three ICEEP conferences are available online at http://www.iceep.org/ and, because access to the contents is otherwise quite limited, the tables of contents are reproduced here (Tables 1.2—1.4).

Unfortunately, access to the proceedings of the first three conferences is limited because they were published as one-off standalone books and are not indexed by the Web of Science aggregating database or PubMed.[64—66] Lack of indexing means that the articles in these first three publications do not appear in most web-based literature searches (e.g., Web of Science, PubMed) and are easily missed. Citations to articles in these proceedings do index in Google Scholar, and a review of the citation counts for these articles reveals just how influential they have been (see Tables 1.2—1.4). These citation rates are quite remarkable and evidence of the impact of both the conferences and the quality of work represented by these publications.

The proceedings of ICEEPs 4 to 8 were published as supplements to the *Equine Veterinary Journal,* and articles in those proceedings are easily located by routine literature searches.[67—70] The proceedings of ICEEP 1 to 5 were published in the year after the conference, whereas the proceedings for ICEEPs 6 to 8 were published immediately before the conference and available to those participating in the meeting. Financial constraints and changes in scientific publication meant that it was not possible to produce proceedings of ICEEPs 9 to 11 as a single compendium of full-length articles. The compromise was to publish abstracts online.[71,72]

The influence of the ICEEP conferences can be judged, in part, by the number of articles published in the respective proceedings and by the number of citations of these articles (Table 1.5). Articles in the first 3 proceedings were cited an average of 26 to 35 times, with 42 articles (21%) having at least 40 citations. To put this in context, of the 500 most cited articles in veterinary science (which includes equine exercise physiology) from 2010 to 2014, only one-half have 40 or more citations,[73] indicating that one-fifth of the early publications in the ICEEP proceedings clearly rank among the most cited articles in veterinary science—and this for publications that are not indexed by PubMed or Web of Science. The reasons for this remarkable influence include that each manuscript was rigorously reviewed, contributors sought to submit their "best stuff," such was the acclaim that was so quickly associated with the conferences and their proceedings, and the early articles were sentinel or pioneering studies. These proceedings were given to all who attended. Other copies were sold to interested buyers via direct mail advertising and various equine-related newsletters. Many copies found their way to veterinary school libraries around the world to serve as reference texts and, doubtless, many of the citations listed in Tables 1.2 through 1.4 emanated from these sources, encouraging others to pursue studies focused on equine exercise and to attend future ICEEPs. However, the larger exercise physiology academic community was largely unaware of the existence of these proceedings. Had that not been the case, the impact of the proceedings from ICEEPs 1 to 3 would probably have been even greater, although citation rates for the most recent full ICEEP proceedings (ICEEPs 6 to 8), which are widely indexed, are not as high (see Table 1.5) and 40 articles (12%) have attracted 40 or more citations. However, these articles have not had the same amount of time to attract citations.

It is clear that the proceedings of ICEEP 1 to 8 were essential to the development and progress of equine exercise science and are a valuable resource and important repository of fundamental information and knowledge.

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TABLE 1.2 Articles Published in the Proceedings of the First ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021

Title	Page Number	Times Cited 1983–2021
Respiratory System		
Respiratory function in the exercising horse. A review. Gillespie J. R. and Pascoe J. R.	1	9
Respiration in exercising horses. Hornicke H., Meixner R. and Pollmann U.	7	110
Respiration and locomotion. Attenburrow D. P.	17	36
Respiratory air flow and sound intensity. Attenburrow D. P., Flack F. C., Hornicke H., Meixner R. and Pollman U.	23	15
Resonant frequency of the lateral ventricle and saccule and "whistling." Attenburrow D. P.	27	12
Cardiorespiratory adaptations to exercise in riding horses with chronic lung disease. Littlejohn A., Bowles F. and Aschenborn G.	33	12
Laryngeal asynchrony in the horse: definition and significance. Baker G. J.	46	46
Exercise induced pulmonary haemorrhage in horses after different competitive exercises. Sweeney C. R. and Soma L. R.	51	32
Exercise induced pulmonary haemorrhage in horses. Mason D. K., Collins E. A. and Watkins K. L.	57	13
Effects of furosemide on exercise-induced alterations in haemostasis in Thoroughbred horses exhibiting post-exercise epistaxis. Bayly W. M., Meyers K. M., Keck M. T., Huston L. J. and Grant B. D.	64	40
Determination of the site of airway obstruction using gases of differing density. Robinson N. E., Derksen F. J. and Slocombe R. F.	71	3
Cardiovascular System		
Cardiovascular response to exercise in the horse. A review. Fregin G. F. and Thomas D. P.	76	41
Transmural coronary vasodilator reserve in ponies at rest and during maximal exercise. Manohar M. and Parks C.	91	5
Transmural distribution of myocardial blood flow during graded treadmill exercise in ponies. Parks C. M. and Manohar M.	105	6
Heart score: physiological basis and confounding variables. Physick-Sheard P. W. and Hendren C. M.	121	19
A comparison of electrocardiographic findings in racehorses presented either for routine examination or poor racing performance. Stewart J. H., Rose R. J., Davis P. E. and Hoffman K.	135	14
The effects of vertical force on blood flow in the palmar digital arteries of the horse. Kraayenburg van F. J., Fairall N. and Littlejohn A.	144	11
Capillary filtration in the equine digit. Korthuis R. J., Wang C. Y., Robinson N. E. and Scott J. B.	155	8
Muscular System		
Skeletal muscle adaptations: A review. Snow D. H.	160	90
Correlated histochemistry and morphometry in equine skeletal muscle. Hoppeler H., Claassen H., Howald H. and Straub R.	184	8
The use of morphometry and enzyme activity measurements in skeletal muscles for the assessment of the working capacity of horses. Straub R., Dettwiler M., Hoppeler H. and Claassen H.	193	13
Skeletal muscle characteristics of young Standardbreds in relation to growth and early training. Essen-Gustavsson B., Lindholm A., McMiken D., Persson S. and Thornton J.	200	74
Muscle histochemistry and biochemistry of Thoroughbred horses during growth and training. Lindholm A., Essen-Gustavsson B., McMiken D., Persson S. and Thornton J.	211	66
Skeletal muscle characteristics of foals at two to four weeks and eight months of age. Thornton J. R. and Taylor A. W.	218	12

(*continued on next page*)

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TABLE 1.2 **Articles Published in the Proceedings of the First ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)**

Title	Page Number	Times Cited 1983–2021
A histochemical assessment of the capillary blood supply of the middle gluteal muscle of Thoroughbred horses. Henckel P.	225	15
Muscle glycogen depletion and repletion patterns in horses performing various distances of endurance exercise. Hodgson D. R., Rose R. J. and Allen J. R.	229	48
Changes in muscle glycogen, lactate and pyruvate concentration in the Thoroughbred horse following maximal exercise. Nimmo M. A. and Snow D. H.	237	33
Gait		
Remarks on gait analysis. Pratt Jr. G. W.	245	20
A quantitative force plate assessment of equine locomotor performance. Goodship A. E., Brown P. N., MacVie H. J. H., Lanyon L. E. and Silver I. A.	263	25
Morphological attributes associated with speed of running in horses. Gunn H. M.	271	23
Nutrition		
Nutritional requirements of the exercising horse. A review. Hintz H. F.	275	28
Thermoregulation, Fluid and Electrolyte Balance		
Thermoregulation and fluid balance in the exercising horse. Carlson G. P.	291	108
Investigations on sodium metabolism in exercised Shetland ponies fed a diet marginal in sodium. Schmidt M. and Meyer H.	310	15
Haematology		
Physiological factors affecting resting haematology. Snow D. H.	318	11
The significance of haematological data in the evaluation of soundness and fitness in the horse. Persson S. G. B.	324	27
Effects of training and time of day of blood sampling on the variation of some common haematological parameters in normal Thoroughbred racehorses. Allen B. V. and Powell D. G.	328	34
Exercise-induced alterations in haemostasis in Thoroughbred horses. Bayly W. M., Meyers K. M., Keck M. I., Huston L. J. and Grant B. D.	336	40
Training and Blood Biochemistry		
I. Resting		
The biochemistry and haematology of inherent performance. Blackmore D. J.	344	7
Plasma biochemical values in Thoroughbred horses in training. Judson G. J., Mooney G. J. and Thornbury R. S.	354	9
The influence of racing on selected serum enzymes, electrolytes and other constituents in Thoroughbred horses. Sommer H. and Felbinger U.	362	7
Preliminary studies on the relationship of red blood cell potassium concentration and performance. Muylle E., Hende van den C., Nuytten J., Oyaert W. and Vlaminck K.	368	34
Body water and water turnover rate in Thoroughbred horses in training. Judson G. J. and Mooney C. J.	371	10
The role of hormones in exercise physiology. Irvine C. H. G.	377	26
II. Exercising		
Post-race blood biochemistry in Thoroughbreds. Snow D. H., Mason D. K., Ricketts S. W. and Douglas T. A.	389	95
The effects of maximal exercise on acid-base balance and arterial blood gas tension in Thoroughbred horses. Bayly W. M., Grant B. D., Breeze R. G. and Kramer J. W.	400	111
Biochemical changes in Thoroughbred racehorses following submaximal and maximal exercise. Judson G. J., Frauenfelder H. C. and Mooney G. J.	408	47
Haematology and blood biochemistry of horses during a 210 km endurance ride. Grosskopf J. F. W., Rensburg van J. J. and Bertschinger H. J.	416	28

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TABLE 1.2 Articles Published in the Proceedings of the First ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)

Title	Page Number	Times Cited 1983–2021
Some observations on the haematology and blood biochemistry of horses competing in 80 km endurance rides.	425	27
Plasma enzyme activities in endurance horses. Kerr M. G. and Snow D. H.	432	25
Analysis of Fitness and State of Training		
Evaluation of exercise tolerance and fitness in the performance horse. Persson S. G. B.	441	212
Cardiorespiratory and metabolic effects of training of Standard bred yearlings. Persson S. G. B., Essen-Gustavsson B., Lindholm A., McMiken D. and Thornton J. R.	458	49
Effects of training and detraining on oxygen uptake, cardiac output, blood gas tensions, pH and lactate concentrations during and after exercise in the horse. Thornton J., Essen-Gustavsson B., Lindholm A., McMiken D. and Persson S.	470	146
Heart rate, lactic acid production and speed during a standardized exercise test in Standardbred horses. Wilson R. G., Isler R. B. and Thornton J. R.	487	90
Some physiological responses of Standardbred horses to a submaximal exercise test following conventional and interval training. Gabel A. A., Milne D. W., Muir W. W., Skarda R. T. and Weingold M. F.	497	9
An evaluation of heart rate and respiratory rate recovery for assessment of fitness during endurance rides. Rose R. J.	505	18
Drugs		
Drugs and equine performance: A review. Tobin T., Kamerling S. and Nugent T. E.	510	4
A double blind study of the effects of amphetamine and methylphenidate on physiological parameters in Standardbred horses performing submaximal exercise tests. Gabel A. A., Milne D. W., Ray R. S., Sams R., Muir W. W., Skarda R. T. and Weingold M. F.	521	3
A study of the effects of methylprednisolone, promazine, amphetamine and furosemide on physiological parameters in Standardbred horses performing a submaximal exercise test. Gabel A. A., Milne D. W., Ray R. S., Noonan J., Muir W. W., Skarda R. T. and Weingold M. F.	531	4
Effects of theophylline and non-steroidal anti-inflammatory drugs on pulse and blood lactate responses to exercise in the horse: A preliminary report. Kallings P. and Persson S.	538	6

The articles are available at the ICEEP website (http://www.iceep.org/past.html).
Equine Exercise Physiology. Proceedings of the first international conference. In: Snow DH, Persson SGB, Rose RJ, eds. *International Conference on Equine Exercise Physiology*. Oxford: Granta Editions, Cambridge; 1983:543.

A History of ICEEP

The Formative Conferences: ICEEPs 1 Through 3

The first ICEEP set the stage, and standard, for subsequent ICEEP conferences, including strong participation by the leading scientists and veterinarians in this field, mentorship of emerging scientists, support by sponsors, and publication of peer-reviewed articles in a conference proceedings. The topics at the first ICEEP included[64] respiratory system, cardiovascular system, muscular system, gait, nutrition, thermoregulation, fluid and electrolyte balance, hematology, training and blood biochemistry, training and assessment of fitness, and drugs. Forty years on, ICEEP 11 in Sweden is based on the topics of applied physiology (new technology in equine exercise physiology, drugs in equestrian sport and exercise, training, genetics and other topics), nutrition, cardiorespiratory, biomechanics and locomotion, physiotherapy, rehabilitation and equitation science, biochemistry, hematology, endocrinology and thermoregulation in exercise, and muscle, reflecting the prescience of the organizers of the first ICEEP.

ICEEP 1 was held over 3 days in Oxford in September 1982 and attended by 150 people from 21 countries. It opened with a presentation from Bengt Saltin, at that time the world's best known comparative exercise physiologist, and approximately 59 presentations and posters and an evening of small group workshop discussions followed. The inclusion of several excellent review presentations was warmly received and set a precedent for future ICEEPs—and these publications are among the most cited from that conference (see Table 1.2). Of the specific topics covered in

(text continued on p. 16)

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TABLE 1.3 Articles Published in the Proceedings of the Second ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021

Title	Page Number	Times Cited 1987–2021
Cardiopulmonary System		
Cardiovascular and respiratory function in the athletic horse. R. J. Rose and D. L. Evans.	1	59
Effect of training on modal planar vectors during ventricular depolarization in Thoroughbred horses using a tetrahedron lead system. J. Hanak.	25	4
Echocardiographic changes with endurance training. K. S. Paull, W. E. Wingfield, J. J. Bertone and J. A. Boon.	34	21
Cardiopulmonary response to exercise and retraining in the Quarter Horse. H. H. Erickson, W. L. Sexton, B. K. Erickson and J. R. Coffman.	41	17
Maximum oxygen uptake in racehorses: changes with training state and prediction from submaximal cardiorespiratory measurements. D L. Evans and R. J. Rose.	52	86
Standardized exercise test on a track to evaluate fitness and training of saddle horses. M. M. Sleet van Oldruitenborgh-Oosterbaan, T. H. Wensing and H. J. Breukink.	68	34
Cardiopulmonary and metabolic responses to exercise in the Quarter Horse: effects of training. W. L. Sexton, H. H. Erickson and J. R. Coffman.	77	33
Performance evaluation and detection of injury during exercise training in the Quarter Horse using a heart rate computer. B. K. Erickson, H. H. Erickson, W. L. Sexton and J. R. Coffman.	92	24
Evaluation of factors influencing the performance of four equine heart rate meters. P. W. Physick-Sheard, I. C. Harman, D. H. Snow and A. J. Woakes.	102	14
Cardiorespiratory effects of clenbuterol in fit Thoroughbred horses during a maximal exercise test. R. J. Rose and D. L. Evans.	117	22
Furosemide and systemic circulation during severe exercise. M. Manohar.	132	11
Respiratory gas exchange kinetics in transition from rest or prior exercise in ponies. S. K. Powers, R. E. Beadles, J. Lawler, and D. Thompson.	148	6
Relationships between arterial oxygen tensions und cardiocirculatory and pulmonary function at rest and during submaximal exercise in the horse. S. G. B. Persson, P. Maltings and C. Ingvast-Larsson.	161	15
Ventilatory response to exercise in horses with exercise-induced hypoxemia. W. M. Bayly, D. A. Schulz, D. R. Hodgson and P. D. Gollnick.	172	30
Body temperature changes in horses during riding: time course and effects on heart rate and respiratory frequency. M. Thiel, G. Tolkmitt and H. Hörnicke.	183	15
The measurement of respiratory airflow in exercising horses. A. J. Woakes, P. J. Butler and G. H. Snow.	194	49
The oxygen cost of weight loading and inclined treadmill exercise in the horse. J. Thornton, J. Pagan and S. Persson.	206	62
Pulmonary ventilation in Thoroughbred horses at maximum performance. H. Hörnicke, M. Weber and W. Schweiker.	216	21
Effect of sub-maximal exercise and training on dead space ventilation in the horse. N. Pelletier, D. Blais, A. Vrins and N. E. Robinson.	225	19
Effects of a cold environment on exercise tolerance in the horse. L.-G. Dahl, J. R. Gillespie, P. Killings, S. G. B. Persson and J. R. Thornton.	235	19
Alveolar macrophage function in Thoroughbreds after strenuous exercise. L. J. Huston, W. M. Bayly, H. D. Liggitt and N. S. Magnuson.	243	22
Muscle, bone and fat proportions and the muscle distribution of Thoroughbreds and other horses. H. M. Gunn.	253	93
Muscle fiber type changes in the middle gluteal of Quarter and Standardbred horses from birth through one year of age. P. I. Bechtel and K. H. Kline.	265	29

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TABLE 1.3 **Articles Published in the Proceedings of the Second ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)**

Title	Page Number	Times Cited 1987–2021
Changes in muscle fiber type variation within the middle gluteal of young and mature horses as a function of sampling depth. K. H. Kline, L. M. Lawrence, J. Novakotski and P. J. Bechtel.	271	29
Relating maximal oxygen consumption to skeletal muscle mitochondria in horses. H. Hoppeler, I. H. Jones, S. L. Lindstedt, H. Claassen, K. E. Longworth, C. R. Taylor, R. Straub and A. Lindholm.	278	33
Metabolic response to racing determined in pools of type I, IIA and HB fibers. S. Valberg and B. Essen-Gustavsson.	290	58
Responses to repeated high intensity exercise: influence on muscle metabolism. D. R. Hodgson, T. B. Kelso, W. M. Bayly and P. D. Gollnick.	302	12
Effects of maximal exercise on equine muscle: changes in metabolites, pH and temperature. D. K. Lovell, T. A. Reid and R. J. Rose.	312	24
Influence of post-exercise activity on rates of muscle and blood lactate disappearance in the Thoroughbred horse. D. I. Marlin, R. C. Harris, I. C. Harman and D. H. Snow.	321	35
Changes in free and bound carnitine in muscle with maximal sprint exercise in the Thoroughbred horse. C. V. M. Foster and R. C. Harris.	332	17
Skeletal muscle buffer capacity changes in Standardbred horses: effects of growth and training. G. Fox, P. Henckel, C. Juel, J. Falk-Ronne and B. Saltin.	341	11
Buffering and aerobic capacity in equine muscle: variation and effect of training. L. J. McCutcheon, T. B. Kelso, A. Bertocci, D. R. Hodgson, W. M. Bayly and P. D. Gollnick.	348	19
Gel electrophoresis of proteins from single equine muscle fibers. R. Billeter, J. Lador, H. Howald and R. Straub.	359	6
Skeletal muscle adaptation in racehorses following high intensity interval training. R. G. Wilson, J. R. Thornton, S. Inglis and J. Ainscow.	367	14
A field study of circulatory response and muscle characteristics in young Thoroughbreds. M. Roneus, B. Essén-Gustavsson, A. Lindholm and S. Persson.	376	23
Cardio-respiratory and muscle metabolic responses to draught work on a treadmill in Standardbred horses. M. Gottlieb, B. Essén-Gustavsson, A. Lindholm and S. G. B. Persson.	384	12
Blood Chemistry, Body Fluids and Hematology		
Hematology and body fluids in the equine athlete: A review. G. P. Carlson.	393	133
Lactate concentrations in Thoroughbred horses following maximal exercise under field conditions. W. M. Bayly, B. D. Grant and R. C. Pearson.	426	62
Bicarbonate administration and muscle metabolism during high-intensity exercise. T. B. Kelso, D. R. Hodgson, E. H. Witt, W. M. Bayly, B. D. Grant and P. D. Gollnick.	438	39
The effect of sodium bicarbonate ingestion on blood parameters in exercising horse. L. M. Lawrence, P. A. Miller, P. J. Bechtel, R. A. Kane, E. V. Kurcz and J. S. Smith.	448	26
Blood and muscle ammonia concentrations in horses during treadmill work and after racing. B. Essén-Gustavsson and S. Valberg.	456	20
Acute changes in the water content and density of blood and plasma in the Thoroughbred horse during maximal exercise: relevance to the calculation or metabolite concentrations in these tissues and in muscle. R. C. Harris, J. C. Harman, D. I. Marlin and D. H. Snow.	464	23
The effect of submaximal treadmill training on heart rate, lactate and ammonia in Quarter Horses. P. A. Miller and L. M. Lawrence.	476	21
Effect of exercise and training on erythrocyte content of 2,3-DPG and oxygen content of blood in the horse. N. Pelletier, D. Blais and A. Vrins.	485	4
Field observations on selenium status, whole blood glutathione peroxidase and plasma gamma-glutamyl transferase activities in Thoroughbred racehorses. D. H. Snow, S. P. Gash and D. Rice.	494	16

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TABLE 1.3 **Articles Published in the Proceedings of the Second ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)**

Title	Page Number	Times Cited 1987–2021
The effect of exercise on plasma adrenocorticotrophin, cortisol and insulin in the horse and adaptations within training. D. B. Church, D. E. Evans, D. R. Lewis and R. J. Rose.	506	65
Locomotor System		
Locomotion of the athletic horse. D. Leach.	516	39
Computerized force plate determination of equine weight-bearing profiles. H. J. Seeherman, E. A. Morris and G. E. Fackelman.	536	27
Redistribution of ground reaction forces in experimentally induced equine carpal lameness. E. A. Morris and H. I. Seeherman.	553	60
Individual variation in the Quarter Horse gallop. N. R. Deuel and L. M. Lawrence.	564	16
Locomotor forces of galloping horses. M. H. Ratzlaff, B. D. Grant, J. M. Frame and M. L. Hyde.	587	31
A method to analyze forces and moments in the extremities of the horse during the stance phase at the trot. G. Hjertén and S. Drevemo.	587	24
Kinematics of the equine carpus. S. Palmer, D. Barlow and J. I. Chun.	599	7
Kinematics of the thoracolumbar spine of the horse during dorsoventral movements: a preliminary report. J. M. Denoix.	607	46
Noninvasive measurement of bone quality in horses and changes associated with exercise. L. B. Jeffcott, S. H. W. Buckingham and R. N. McCartney.	615	34
Changes in bone strength and density in Standardbreds from weaning to onset of training. S. H. W. Buckingham and L. B. Jeffcott.	631	16
Nutrition		
Nutrition of the equine athlete. H. Meyer.	644	122
Effect of dietary fit on blood parameters in exercised Thoroughbred horses. S. E. Duren, S. G. Jackson, J. P. Baker and D. K. Aaron.	674	38
The effect of dietary energy source on exercise performance in Standardbred horses. J. D. Pagan, B. Essen-Gustavsson, A. Lindholm and J. Thornton.	686	102
Glycogen depletion following different diets. D. H. Snow, R. C. Harris, J. C. Harman and D. J. Marlin.	701	23
Pathophysiology		
Pathophysiology of exercise induced diseases of the musculoskeletal system of the equine athlete. A. Lindholm.	711	26
Vascular changes in the lungs of horses with exercise-induced pulmonary hemorrhage. M. W. O'Callaghan, J. R. Pascoe, W. S. Tyler and D. K. Mason.	728	3
Histologic features of lungs from Thoroughbred horses with a history of exercise-induced pulmonary hemorrhage. W. S. Tyler, J. R. Pascoe, M. W. O'Callaghan and D. K. Mason.	738	2
Changes in arterial oxygen tension in COPD horses after reduction of exposure to dust in the feed and environment. C. Kvart, J. Christen and L. Ryden.	753	5
Characteristics of respiratory airflow during exercise in horses with reduced performance due to pulmonary emphysema or bronchitis. U. Pollmann and H. Hornicke.	760	6
Exercise tolerance in Standardbred trotters with T-wave abnormalities in the electrocardiogram. S. G. B. Persson and P. Forssberg.	772	16
Cardiac arrhythmias on the racecourse. J. R. Holmes.	781	10
Exertional rhabdomyolysis related to malignant hyperthermia using the halothane-caffeine contracture test. S. V. Hildebrand, D. Arpin, and G. H. Cardinet.	786	4
Enzyme histochemistry in exertional myopathy. R. van den Hoven, T. H. Wensing, H. L. Breukink and A. E. F. H. Meijer.	796	8

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TABLE 1.4 Articles Published in the Proceedings of the Third ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021

Title	Page Number	Times Cited 1991–2021
Cardiovascular Responses to Exercise		
Respiratory muscle perfusion during strenuous exercise. M. Manohar.	1	7
Cardiopulmonary effects of acute blood volume alteration prior to exercise. M. K. Hopper, R. L. Pieschl Jr, N. G. Pelletier and H. H. Erickson.	9	39
Heart and spleen weights as a function of breed and somatotype. H. Kline and J. H. Foreman	17	31
Electrocardiographic and echocardiographic measurements and their relationships in Thoroughbred yearlings to subsequent performance. D. Leadon, H. McAllister, E. Mullins and M. Osborne.	22	25
Hypoxia does not contribute to high pulmonary artery pressure in exercising horses. N. Pelletier and D. E. Leith.	30	6
Standardized exercise test on a track to evaluate exercise capacity in different breeds of horses. E. Cikrytova, B. Kostelecka, J. Kovar, F. Hordk and J. Hanak.	37	16
Indices of performance in the racing Quarter Horse. H. H. Erickson, C. S. Lundin, B. K. Erickson and J. R. Coffman.	41	21
Respiratory Responses to Exercise		
Heliox-induced changes in the breathing mechanics of ponies during exercise. T. Art, D. Desmecht, H. Amory and P. Lekeux.	47	5
Alleviation of exercise-induced hypoxemia utilizing inspired 79% Helium 20.95% Oxygen. B. K. Erickson, R. L. Pieschl and H. H. Erickson.	54	13
No ventilatory response to CO_2 in Thoroughbreds galloping at 14 m s- 1. G. L. Landgren, J. R. Gillespie and D. E.	59	16
1:2 ratio of breathing to stride frequencies in a galloping horse breathing 6% CO_2. J. R. Gillespie, G. L. Landgren and D. E. Leith.	66	22
The effect of cessation of training on cardiorespiratory variables during exercise. P. J. Butler, A. J. Woakes, L. S. Anderson, K. Smale, C. A. Roberts and D. H. Snow.	71	135
Effects of training intensity on maximum oxygen uptake. P. K. Knight, A. K. Sinha and R. J. Rose.	77	72
Effect of treadmill exercise on intrapleural, transdiaphragmatic and intraabdominal pressures in Standardbred horses. R. Slocombe, K. Brock, G. Covelli and W. Bayly.	83	19
Draught load and speed compared by submaximal tests on a treadmill. M. Gottlieb-Vedi, B. Essen-Gustavsson and S. G. B. Persson.	92	12
Locomotion		
Shock and vibration during the hoof impact on different track surfaces. E. Barrey, B. Landjerit and R. Wolter.	97	103
Evaluation of a shock absorbing woodchip layer on a harness racetrack. S. Drevemo and G. Hjerten.	107	16
Center of pressure location of the hoof with and without hoof wedges. P. Colahan, D. Leach and G. Muir.	113	24
Ground reaction force analysis of horses ridden at the walk and trot. H. C. Schamhardt, H. W. Merkens and G. J. V. M. van Osch.	120	55
Ground reaction force analysis of Dutch warmblood horses at canter and jumping. H. W. Merkens, H. C. Schamhardt, G. J. V. M. van Osch and A. J. van den Bogert.	128	24
Velocity-dependent changes in stride frequency and length of trotters on a treadmill. D. H. Leach and S. Drevemo.	136	31
Velocity-dependent changes in intrinsic stride timing variables of Quarter horse foals. G.D. Muir, D. H. Leach, N. Cymbaluk and S. Dyson.	141	9
Neck muscles activity in horses during locomotion with and without a rider. M. L Tokuriki and O. Aoki.	146	29

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TABLE 1.4 **Articles Published in the Proceedings of the Third ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)**

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Stride characteristics of four Grand Prix jumping horses. H. M. Clayton and D. A. Barlow.	151	54
Kinematic analysis of jumping sequences of Olympic show jumping horses. N. R. Deuel and J. Park.	158	45
Hoof landing velocities in trotting horses. C. Johnston, G. Hjerten and S. Drevemo.	167	20
Muscular Responses to Exercise		
Lactate kinetics, plasma ammonia and performance following repeated bouts of maximal exercise. R. C. Harris, D. J. Marlin and D. H. Snow.	173	22
Plasma lactate kinetics during exercise. E. K. Birks, J. H. Jones, L. J. Vandervort, A. K. Priest and J. D. Berry.	179	31
Rates of blood lactate disappearance following exercise of different intensities. D. J. Marlin, R. C. Harris and D. Snow.	188	36
Reproducibility and validity of VLA 4 in Standard bred pacer horses on track. M. Bourgela, D. Blais and M. Marcoux.	196	12
Exercise-induced changes in muscle and plasma amino acid levels in the Standardbred horse. A. R. Posa, B. Essen-Gustavsson, A. Lindholm and S. G. B. Persson.	202	27
The effect of monosodium glutamate infusion on time to fatigue. D. E. Beaunoyer, S. G. Jackson, J. R. Gillespie and J.P. Baker.	209	5
Changes in skeletal muscle composition in response to interval and high intensity training. D. K. Lovell and R. J. Rose.	215	47
Effect of training intensity and detraining on adaptations in different skeletal muscles. A. K. Sinha, S. P. Ray and R. J. Rose.	223	18
Energy profile and the locomotor pattern of trotting on an inclined treadmill. S. G. B. Persson, B. Essen-Gustavsson and A. Lindholm.	231	22
Capillary supply in relation to muscle metabolic profile and cardiocirculatory parameters. K. Karlstrom, B. Essen-Gustavsson, A. Lindholm and S. G. B. Persson.	239	21
Growth changes in skeletal muscle histochemistry of Thoroughbreds and other horses. H. M. Gunn.	245	7
Muscle carnosine content is unchanged during maximal intermittent exercise. R. C. Harris, M. Dunnett and D. H. Snow.	257	5
Fibre composition and tubulin localization in muscle of Thoroughbred sprinters and stayers. V. Horak, P. Draber, J. Hanak and S. Matolin.	262	3
Ultrastructural alterations in equine skeletal muscle associated with fatiguing exercise. L. J. McCutcheon, S. K. Byrd, D.R. Hodgson and P. D. Gollnick.	269	8
Carnosine accounts for most of the variation in physico-chemical buffering in equine muscle. D. A. Sewell, R. C. Harris and M. Dunnett.	276	8
Nutrition of the Performance Horse		
Energy use and cardiorespiratory responses to prolonged submaximal exercise. R. J. Rose, P. K. Knight and W. L. Bryden.	281	19
Influence of diet on substrate metabolism during exercise. B. Essen-Gustavsson, E. Blomstrand, K. Karlstrom, A. Lindholm and S. G. B. Persson.	288	19
Effects of daily exercise on muscle glycogen in the Thoroughbred racehorse. D. H. Snow and R. C. Harris.	299	53
Effect of dietary protein level on nitrogen metabolites in exercised Quarter Horses. P. Miller-Graber, L. Lawrence, J. Foreman, K. Bump, M. Fisher and E. Kurcz.	305	40
The effect of vitamin E on membrane integrity during submaximal exercise. K. H. Petersson, H. F. Hintz, H. F. Schryver and G. F. Combs Jr.	315	16

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TABLE 1.4 **Articles Published in the Proceedings of the Third ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)**

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Glycemic and endocrine responses to corn or alfalfa fed prior to exercise. A. Rodiek, S. Bonvicin, C. Stull and M. Arana.	323	20
Hematological, Body Fluid and Acid Base Changes With Exercise		
Work load in the horse during vaulting competition. M. M. Sloet van Oldruitenborgh-Oosterbaan, Th. Wensing, A. Barneveld and H. J. Breukink.	331	33
Multivariate analysis of exercise parameters measured during an incremental treadmill test. J.-P. Valette, E. Barrey and R. Wolter.	337	17
Effects of acetazolamide on cardiorespiratory and metabolic responses to submaximal exercise. D.R. Hodgson, R. J. Rose, L. J. McCutcheon, T. B. Kelso, W. M. Bayly and P. D. Gollnick.	343	36
Metabolic alkalosis and exercise performance in the Thoroughbred horse. P. L. Greenhaff, J. Hanak, R. C. Harris, P. Dobias, P. Jahn, J. Skalicky and D. H. Snow.	353	4
Renal responses to high intensity exercise. H. C. Schott II, D.R. Hodgson, W. M. Bayly and P. D. Gollnick.	361	21
Atrial natriuretic peptide during exercise in horses. K. H. McKeever, K. W. Hinchcliff, L. M. Schmall, D. R. Lamb and W. W. Muir III.	368	23
Effects of exercise on plasma concentrations of prostaglandins and thromboxane B2. E. K. Birks, S. N. Giri, C. Li and J. H. Jones.	374	18
Effects of exercise and metabolic alkalosis on selected plasma amino acid concentrations in Thoroughbred racehorses. P. Jahn, I. Liska, J. Handk, D. Snow, P. Greenhaff, P. Dobids, B. Kosteleckd and J. Skalicky.	380	13
Heart rate, hematological and serum biochemical responses to show jumping. P. Lekeux, T. Art, A. Linden, D. Desmecht and H. Amory.	385	7
Effect of 5 different types of exercise, transportation and ACTH administration on plasma cortisol concentration in sport horses. A. Linden, T. Art, H. Amory, D. Desmecht and P. Lekeux.	391	72
Blood volume, lactate and cortisol in exercising Arabian equitation horses. S. J. Wickler and W. Troy.	397	84
Pathophysiological Phenomena Associated With Exercise and/or Conditioning		
Scintigraphic appearance of dorsal metacarpal and metatarsal stress changes in racing and nonracing horses. J. H. Foreman, L. L. Hungerford, A. R. Twardock and G. J. Baker.	402	10
Skeletal effects of a long term submaximal exercise programme on Standardbred yearlings. S. H. W. Buckingham and L. B. Jeffcott.	411	4
Treadmill exercise intensity and its effects on cortical bone in horses of various ages. R. N. McCarthy and L.B. Jeffcott.	419	15
The Glyco(geno)lytic capacity of skeletal muscle in horses with exertional rhabdomyolysis. S. J. Valberg and G. H. Cardinet III.	429	14
Role of electrolyte imbalances in the pathophysiology of the equine rhabdo- myolysis syndrome. P.A. Harris and D. H. Snow.	435	6
Treatment of left laryngeal hemiplegia using a nerve muscle pedicle graft. C. Fulton, F. J. Derksen, J. A. Stick, N. E. Robinson and R. Walshaw.	443	39
Clinical method for evaluation of upper airway function. K. Holm, B. Funkquist and N. Obel.	449	50
Lung biopsy pathology and exercise tolerance in horses with chronic bronchiolitis. S. G. B. Persson and R. Lindberg.	457	4
Cardiorespiratory and metabolic effects of propranolol during maximal exercise. C. Plummer, P. K. Knight, S. P. Ray and R. J. Rose	465	23
T-waves in the equine electrocardiogram: Effects of training and implications for race performance. D. L. Evans.	475	15

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TABLE 1.4 Articles Published in the Proceedings of the Third ICEEP, With the Number of Citations of Each Article Between the Time of Publication and July 2021 (*continued*)

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The effect of training on adrenocortical function in Thoroughbred racehorses. W. D. Wilson, S. Kingery and D. H. Snow.	482	8
Effects of ozone on exercising horses: A preliminary report. W. Tyler, J. Jones, E. Birks, J. Pascoe, E. Steffey, K. Jarvis, D. Hinds and B. Tarkington.	490	10
Influence of anabolic steroids on the response to training of 2 year old horses. J. R. Thornton, K. F. Dowsett, R. Mann and D. A. V Bodero.	503	8

The articles are available at the ICEEP website (http://www.iceep.org/past.html).

TABLE 1.5 Citations for Articles Published in the Proceedings of the First Eight ICEEP Conferences (as of July 20, 2021)

	Number of Articles	Total Number of Citations	Average Number of Citations per Article	Minimum Number of Citations	Maximum Number of Citations
ICEEP 1[64]	59	2083	35	3	212
ICEEP 2[65]	68	2041	30	3	133
ICEEP 3[66]	70	1814	26	3	135
ICEEP 4[67]	89	1174	13	0	49
ICEEP 5[68]	125	3018	24	1	97
ICEEP 6[69]	100	2307	23	0	101
ICEEP 7[70]	117	2140	18	1	95
ICEEP 8[76]	108	2001	19	1	60

ICEEP, International Conference on Equine Exercise Physiology.
ICEEP 1–3 citations were compiled from Google Scholar, and ICEEP 4–8 citations are courtesy of Wiley and sourced from Web of Science and Dimensions databases.

ICEEP 1, those relating to the respiratory system, skeletal muscle, and blood and plasma biochemistry responses to exercise were the most popular as reflected by the number of papers in the proceedings and the impressive number of citations attributed to a number of them (see Table 1.2). Five of the papers have been cited more than 100 times and another 5 on more than 50 occasions. This is extremely impressive given that the average number of citations for scientific papers is fewer than 10 and that established indexing sources did not list these papers.

ICEEP 2 was held in San Diego, California in August 1986 and was considerably bigger in all respects than ICEEP 1, as reflected by the fact that this conference ran for 5 days. Many who attended that conference and subsequent ICEEPs still feel that it was the most exciting ICEEP held in terms of the expectations and energy levels in all the sessions and their associated interludes. The chair of both the International and National Organizing Committees was Jerry Gillespie, who was renowned for his research and publications related to the equine respiratory system. The size of the proceedings numbered 810 pages as compared with the 542 pages that made up the proceedings from ICEEP 1. So large was the number and length of manuscripts submitted that a Publication Subcommittee was formed. This was chaired by one of Gillespie's former doctoral students, Ed Robinson. This may have been the first of the many books that Robinson edited in his illustrious career.

The program and proceedings of ICEEP 2 were divided into 6 sections as compared with the 10 sections that comprised ICEEP 1. For ICEEP 2 the cardiovascular and respiratory sections were merged and, not surprisingly, represented the largest segment of the program. Particularly noteworthy in this section was the first report of the maximum oxygen uptake in racehorses since that of Karlsen and Nadaljak,[14,74] and the first presentation of research

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done at an institution located behind what was known as the "Iron Curtain" at that time.[75] The section on skeletal muscle was also strong and reflected considerable growth in knowledge regarding the response of muscle to individual bouts of exercise and different conditioning protocols, since ICEEP 1. Papers documenting studies of individual muscle fibers and responses of muscles to very-high-intensity exercise garnered a lot of attention and discussion due to the advances in methodologies that enabled these studies to be conducted. Together, the cardiopulmonary ($n = 21$) and muscular ($n = 15$) system sections accounted for more than 50% of the conference's presentations. Proceedings papers from both sections are currently averaging an impressive 28 citations each (see Tables 1.3 and 1.5).

Another notable feature of ICEEP 2 and its proceedings was the increase in interest in the role of nutrition in the equine athlete, including a review that has attracted more than 100 citations. The other review that has been cited more than 100 times is Gary Carlson's review of body fluids and hematology in the equine athlete.[67] Thirty-three pages long and replete with nearly 200 references, this paper should still be required reading for anyone interested in this topic. Carlson also wrote a review on thermoregulation and body fluid balance for the proceedings of ICEEP 1, and that paper has also been cited more than 100 times. When put together, these numbers are fitting indications of the widespread esteem for Carlson and the trail he blazed in advancing understanding of equine fluid dynamics in responses to exercise of all intensities.

It was appropriate that ICEEP 3 was held in Uppsala, Sweden, given the leading roles of Persson and Lindholm and colleagues in the emergence of the modern era of equine exercise science. Fittingly, Persson served as chair of the International Organizing Committee and Lindholm filled the same position on the National Planning Committee (see Table 1.1). The conference was held in July 1990, with 191 registered attendees representing 25 nations. The number of oral presentations was limited to 60, and there were an additional 20 posters and a number of small group workshops. For the first time, a social field trip was included in the program to promote networking opportunities and to provide a break from the intensity and constancy of the conference presentations as well as an opportunity to experience some beautiful Swedish scenery.

Another first for many attendees was their introduction to the Swedish toast to the horse, in which one gets to demonstrate their personal balancing skills, standing with one foot on the table while raising a glass to the horse and its role in the traditional lives of many people and the careers of those attending ICEEP. The toast to the horse, as provided by Professor Peter Kallings, is:

> *There is someone missing, an absent friend not here tonight, the reason why we all are gathered here — namely the horse … Therefore, I propose a toast to the horse: TO THE HORSE!*

The Swedish version, provided by Professor Anna Jansson, is:

> *Tänk om jag hade en sabel, tänk om jag hade en häst!*
>
> *Med sabeln skulle jag sticka, hugga, skära och slå.*
>
> *Och hästen skulle mig bära så att jag sluppe att gå.*
>
> *Nu har jag ingen sabel, nu har jag ingen häst.*
>
> *Jag känner mig miserabel, jag känner mig urless.*
>
> *Så därför skall jag dricka så mycket som jag tål!*
>
> *Och höjer därför glaset och dricker hästens skål.*
>
> *SKÅL!*

Both the social field trip and the toast to the horse have been included in every ICEEP since. Once again, the Swedes were leading the way!

The Middle Years: ICEEPs 4 and 5

The fourth ICEEP was held in Kooralbyn, Queensland, Australia and attended by 185 delegates from more than 20 countries. The International Committee was chaired by another of the original members of this committee, Reuben Rose. As it transpired, he was the last of this visionary group to lead the organization of an ICEEP. ICEEP 4 was particularly noteworthy because it was the first of these conferences held at a venue at which all attendees were lodged and ate their meals. This created an ideal environment for additional networking and spontaneous socializing, which a number of subsequent ICEEP organizing committees emulated. There were 110 oral and poster presentations at ICEEP 4, which easily exceeded the highest number at any of the first three ICEEPs.

ICEEP 4 marked the first time that there were no independently published proceedings for the conference. Due to concerns regarding the difficulties of some researchers in having their previous contributions receive academic credit from their respective institutional promotional committees, papers associated with ICEEP 4 were published as a special supplement to the prestigious *Equine Veterinary Journal* following a more clearly defined peer-review process. Despite the creation of this more academically acceptable process, it transpired that subscribers to this journal did not receive a copy of the supplement because it was not included in their subscription fee. Consequently, although the review process became more acceptable in various promotion processes, the actual distribution of the conference's papers was still not as widespread as had been hoped.

Utsunomiya, Japan was the site selected for ICEEP 5. The Japan Racing Association (JRA) Equine Research Institute is located there and so, in view of the body of work produced from the institute for more than 25 years, it was fitting that conference be held in that city. JRA also

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generously subsidized the travel and accommodation expenses of overseas delegates. This served as an enticing stimulus, and the number of abstracts submitted for inclusion on the program exceeded the previous record established by ICEEP 4. In the end, 47 abstracts were selected for oral presentation, together with 75 posters and 3 New Horizon lectures. Eight workshop sessions completed the program.

Leo Jeffcott from the University of Cambridge, UK, headed the International Organizing Committee for ICEEP 5. The size of the committee had grown to eight at the conclusion of ICEEP 4 with addition of its first Asian representative, Miki Tokuriki. Tokuriki served as a vital go-between for the International Committee and the 18-person National Organizing Committee, which he also chaired. Following the practice that proved so popular in Kooralbyn, all delegates were again housed in the same venue. The conference was also notable for the increase in the number of papers on the biomechanics of exercise, nutrition and the applied physiology of performance. Although the number of papers dealing with cardiorespiratory aspects of exercise was still the largest section, those related to the responses of skeletal muscle to exercise and training were lower than at the previous ICEEPs. The upswing in the number of presentations on biomechanics and applied physiology was to continue in future ICEEPs, while the decrease in the size of the skeletal muscle section was maintained and joined by a decline in the cardiopulmonary section.

A Maturing Science: ICEEP 6

The iconic location of Lexington, Kentucky was selected as the site for the sixth ICEEP, the second to be held in the United States, for September 2002. The International Committee was chaired by Skip Hintz of Cornell University and the National Committee was chaired by Ken Hinchcliff, based at The Ohio State University. The National Committee had a strong representation from Lexington, with Joe Pagan, Laurie Lawrence, and Bob Coleman all living locally (Fig. 1.3). Key to the success of the conference were partnerships with Kentucky Equine Research (owned by Joe Pagan, who had completed his PhD in equine nutrition under Skip Hintz) and USA Equestrian (represented by John Lengel), which provided valuable financial and logistical support. Staff from Kentucky Equine Research provided most of the local logistical support for the conference, including editorial support for the review process for the proceedings. For the first time, the proceedings were published in advance of the conference and were available to attendees on arrival at the venue.

More than 190 people attended the conference, which was held at the Griffin Gate Marriott hotel, with some taking advantage of the opportunity to register for only particular days. There was a noticeable increase in the number of female presenters and participants in the conference, especially graduate students and emerging researchers. The conference was preceded by an Equine Sports

• **Fig. 1.3** National Organizing Committee for ICEEP 6 (2002). From left, L. Lawrence, R. Coleman, R. Geor, J. Pagan, J. Foreman, H. Schott, K. Hinchcliff, J. McCutcheon, and W. Bayly. (Image provided by Kenneth Hinchcliff.)

2002 conference for veterinarians and trainers, the profit from which provided support for ICEEP. The conference saw a marked increase in the number of presentations related to nutrition of performance horses (13 of 100), the continued increase in interest in biomechanics (15 presentations), a large number of presentations on musculoskeletal responses to training (18), and a decline in the proportion of articles (8) dealing with the cardiovascular responses to exercise. For the first time, there were research papers describing aspects of molecular genetics (messenger RNA [mRNA] transcription), foreshadowing the increased use of these techniques. There were 12 workshop presentations held over four afternoons, and an extensive social and event program allowed attendees to visit the Kentucky Horse Park and other equine facilities in the area.

ICEEP 7

Fontainebleau, south of Paris, was the site of ICEEP 7. The International Committee was chaired by Birgitta Essen-Gustavsson (Fig. 1.4) and the National Committee by Eric Barrey, with strong support from a local (Fontainebleau) committee including representatives of the mayor's office and of Institute of National Research in Agriculture (INRA). INRA and the town of Fontainebleau were major sponsors of the conference. The conference, attended in part or whole by 250 people (Fig. 1.5), was held in the beautiful Municipal Theatre in the center of Fontainebleau, opposite the former royal castle, with attendees staying at various hotels around the town. Almost 200 abstracts were submitted, and not all abstracts that were presented had full articles in the proceedings, which were again available at the time of the conference.

Reflecting continued emerging interest areas in equine exercise science, one session of the conference was allocated to presentations dealing with endurance exercise (11 papers), and

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• **Fig. 1.4** International Committee at ICEEP 7. David Marlin, Mikki Tokuriki, Warwick Bayly, Pierre Lekeux, Joe Pagan, Birgitta Essen-Gustaffson, Eric Barrey, Ken Hinchcliff (absent, David Hodgson). (Copyright Bertrand NICOLAS/INRAE.)

• **Fig. 1.5** Attendees at ICEEP 7 in Fontainebleau, France in 2006. (Copyright Bertrand NICOLAS/INRAE.)

there was continued strong interest in nutrition (17 papers), including many dealing with glycemic responses to exercise and energy metabolism during exercise, and biomechanics and locomotion (19). There was increasing interest in clinical conditions of athletic horses, with a number of papers reporting on cardiovascular, upper respiratory, lower respiratory and muscle disorders. The use of trackside and emerging technologies (global positioning system) was included in several reports. Presentations reporting use of molecular genetic techniques were made in several parts of the conference, demonstrating their utility in the study of disease and in understanding physiologic responses to exercise and conditioning.

ICEEP 8

Spier Resort, just outside Stellenbosch, north of Cape Town in South Africa, was chosen as the site for the November 2010 ICEEP conference. The International Chair, David Marlin, worked closely with the prominent Johannesburg-based equine veterinarian Terry Casey as chair of the National Committee to organize a satellite conference for veterinarians that immediately preceded the ICEEP conference. Attendance at ICEEP 8 was slightly lower than at other ICEEPs (132, Fig. 1.6) likely because of the cost of travel and participation. Despite this limitation, there were 108 publications from 199 abstracts submitted and accepted for presentation either as posters or oral presentations. The proceedings were again available at the conference, aided by the process of having subject area editors to expedite the review and publication process.

• **Fig. 1.6** Attendees at ICEEP 8 in Stellenbosch (Spier Resort), South Africa, 2010. (Reproduced with permission of David Marlin.)

The conference began with a keynote presentation by Professor Tim Noakes, a world-famous exercise physiologist and clinician. The previous trend to an increase in presentations dealing with fluid and electrolyte balance and thermoregulation (20 articles) and biomechanics (26) continued, as did the decline in articles dealing with cardiovascular (5) and respiratory systems (5). A whole day of the conference was allocated to biomechanics and locomotion, and for the first time, there was a section allocated to genetics of exercise and performance. Similarly, topics of "equitation science" and "physiotherapy and rehabilitation" were included in the conference for the first time. There was a first report at ICEEP of the use of overground endoscopy for the diagnosis of upper respiratory disease in horses. Exercise-induced pulmonary hemorrhage continued to be an area of interest for a number of researchers, as it had been at all previous ICEEP conferences.

Although the conference was a remarkable scientific and social success, it was not a financial success, and this imposed constraints on the organization of ICEEP 9.

ICEEP 9

ICEEP 9 was held for the second time in the United Kingdom, at the Queen at Chester Hotel. The International Committee and National Committee were chaired by Ken Hinchcliff and Cathy McGowan, respectively. The University of Liverpool equine continuing education unit

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• **Fig. 1.7** Attendees at ICEEP 9 in Chester, UK 2014. (Reproduced with permission of David Marlin.)

provided invaluable logistical support and expertise in organizing such events. There were 205 attendees at the conference for one or more of the days (Fig. 1.7). The location was ideal, being easily accessible by train from London and close to Manchester airport.

An interim conference, "Winning Ways," was held on June 16 and 17, 2012 at Aintree racecourse near Liverpool. This conference, designed for practicing veterinarians, was important in restoring the finances of ICEEP.

A conference proceeding incorporating full-length articles was not produced for ICEEP 9 because of changes in scientific publishing, the reticence of journal publishers to produce such a supplement, and the financial risk of ICEEP producing a standalone proceedings. A proceedings incorporating abstracts presented at the conference was published online and hard copies were provided at the conference.[71] The conference had two half days allocated to biomechanics and locomotion and a half day allocated to physiotherapy and rehabilitation. Keynote presentations were made in the areas of nutrition, comparative cardiovascular function, conditioning and recovery, the genetics of equine performance, comparative physiotherapy, history of equine exercise physiology, and skeletal muscle function. There were 122 podium and 34 poster presentations.

ICEEP 10

ICEEP returned to Australia with the 10th conference held in Lorne, Victoria in the second week of November 2018 (Fig. 1.8). The International Committee was chaired by Rene van Weeren and the National Committee by Samantha Franklin of the University of Adelaide. A record 278 people from 25 countries attended the conference, which was held surfside at the Mantra Resort over 5 days. The conference was underwritten by Racing Victoria and opened by the Chair of Racing Victoria. Abstracts of presentations at the meeting were published online.[72]

There were keynote presentations on field exercise testing, equine welfare (a first for the ICEEP), physiotherapy,

• **Fig. 1.8** ICEEP 10. Members of the International and National Committees. From left, Drs. Anna Jansson, Kenneth McKeever, René van Weeren, Lidwien Verdegaal, Brett Tennent-Brown, Chris Whitton, Ken Hinchcliff, Jon Foreman, Cathy McGowan, Warwick Bayly, Ben Ahern, Sam Franklin, Erica McKenzie, and members of the Gunditjamara custodians who provided the welcome to country. (Note that not all committee members are present). (Image provided by the author).

subchondral bone loading in racehorses (bone fatigue), stress and exercise, athlete's heart, genetics and equine performance, and joint and muscle function in humans. The main program had 138 full podium presentations and 40 poster displays, and the social program featured cocktail parties in the bush and beachside seafood dinners. Once again biomechanics had the greatest number of presentations, EIPH and furosemide featured prominently as in all other ICEEPS, and onboard monitoring systems incorporating GPS, ECG and movement were prominent in presentations and the exhibitor booths.

ICEEP 11

Uppsala again hosted ICEEP in June 2022 in a world recovering from, and living with, COVID. The Chair of the International Committee was Dr. Erica McKenzie and that of the National Committee was Dr. Anna Jansson.

The future of ICEEP, and equine exercise science, looks very bright indeed.

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