UNIVERSIDADE ESTADUAL PAULISTA

FACULDADE DE MEDICINA VETERINÁRIA E ZOOTECNIA

ESTUDO DA OCORRÊNCIA DE IMPINGIMENTO DE PROCESSOS ESPINHOSOS DE VÉRTEBRAS TORÁCICAS (KISSING SPINES) EM EQUINOS DAS RAÇAS PURO SANGUE INGLÊS E PURO SANGUE ÁRABE

MARCO AURÉLIO GALLO

Botucatu -SP

Novembro – 2024

UNIVERSIDADE ESTADUAL PAULISTA

FACULDADE DE MEDICINA VETERINÁRIA E ZOOTECNIA

ESTUDO DA OCORRÊNCIA DE IMPINGIMENTO DE PROCESSOS ESPINHOSOS DE VÉRTEBRAS TORÁCICAS (KISSING SPINES) EM EQUINOS DAS RAÇAS PURO SANGUE INGLÊS E PURO SANGUE ÁRABE

MARCO AURÉLIO GALLO

Tese apresentada junto ao Programa de Pós-graduação em Biotecnologia Animal como parte dos requisitos para obtenção do título de Doutor.

Orientadora: Professora Associada Vânia Maria de Vasconcelos Machado.

Coorientador: Professor Gustavo Miranda Zanotto.

Botucatu -SP

Novembro - 2024

G172e

Gallo, Marco Aurélio

Estudo da Ocorrência de Impingimento de Processos Espinhosos de Vértebras Torácicas (Kissing Spines) em Equinos das Raças Puro Sangue Inglês e Puro Sangue Árabe / Marco Aurélio Gallo. -- Botucatu, 2024

67 f. : tabs., fotos

Tese (doutorado) - Universidade Estadual Paulista (UNESP), Faculdade de Medicina Veterinária e Zootecnia, Botucatu

Orientadora: Vânia Maria de Vasconcelos Machado

Coorientadora: Gustavo Miranda Zanotto

1. Radiologia. 2. Dor do dorso. 3. Vértebras. 4. Desempenho atlético. 5. Potros. I. Título.

Sistema de geração automática de fichas catalográficas da Unesp. Dados fornecidos pelo autor(a).

Nome do autor: Marco Aurélio Gallo

Título: ESTUDO DA OCORRÊNCIA DE IMPINGIMENTO DE PROCESSOS ESPINHOSOS DE VÉRTEBRAS TORÁCICAS (KISSING SPINES) EM EQUINOS DAS RAÇAS PURO SANGUE INGLÊS E PURO SANGUE ÁRABE

BANCA EXAMINADORA

Profª. Livre Docente Drª. Vânia Maria de Vasconcelos Machado
Presidente e Orientadora
Departamento de Cirurgia Veterinária e Reprodução Animal
Faculdade de Medicina Veterinária e Zootecnia - UNESP - Botucatu/SP

Prof. Associado IV Dr. Antonio Raphael Teixeira Neto
Membro Titular
Faculdade de Agronomia e Medicina Veterinária - FAV
Universidade de Brasília - DF

Professor Assistente Dr. André Luis Filadelpho
Membro Titular
Departamento Biologia Estrutural e Funcional
Instituto de Biociências da UNESP - Botucatu/SP

Professor Titular Dr. Alexandre Secorun Borges
Membro Titular
Departamento de Clínica Veterinária
Faculdade de Medicina Veterinária e Zootecnia - UNESP - Botucatu/SP

Prof. Classe C Adjunto Dr. Caio de Biasi Mauro
Membro Titular
Departamento de Anatomia, Patologia e Clínicas Veterinárias/EMEVZ
Salvador - BA

DEDICATÓRIA

Dedico este trabalho a todos os seres humanos de boa-fé que acreditam que a pesquisa em ciência tem propósito de traçar trilhas do conhecimento continuado e revelar os enigmas até então desconhecidos dos eventos coordenados que regem a vida animal.

Dedico também a pesquisa a todos os equinos do mundo, ao longo da existência humana e de sua domesticação, que nesta árdua jornada de companheirismo e lealdade, puderam proporcionar a humanidade suas conquistas, implementar a agricultura e o agronegócio como um todo e a contribuir para a ocupação de terras inabitadas.

A nobre espécie que carregou a humanidade apoiada no seu dorso e na tração da leveza dos membros locomotores concedeu-nos a oportunidade de transportar bens de consumo e de conduzir suas famílias pelos continentes.

Além disso, de nos dar o prazer de sua companhia em momentos difíceis. De nos trazer o privilégio de observarmos sua elegância nas competições das quais eles são os protagonistas.

De serem parceiros na produção de produtos biológicos para a cura de doenças. De participarem do patrulhamento da segurança pública urbana e rural.

Dedico este estudo aos equinos de todas as raças, idades e pelagens e rogo que continuem fazendo o que sempre fizeram de melhor, de nos agraciar com a beleza imponente de seus passos, trotes ou galopes.

AGRADECIMENTOS

Agradeço a Deus por ter me proporcionado a vida e saúde.

A orientadora, Profa. Vânia Machado de Vasconcelos por ter me aceitado como orientando, pelas conversas e pelas atividades propostas. Muito obrigado pela paciência e pelo acolhimento.

Agradeço ao meu coorientador Dr. Gustavo Miranda Zanotto pelas conversas e conselhos, pela amizade e pelo carinho demonstrado.

Aos ilustres colaboradores da Faculdade de Medicina Veterinária e Zootecnia da UNESP, notadamente aos colaboradores do Sistema de Pós-Graduação, pelo empenho e dedicação prestados a mim nesta trajetória.

Ao Departamento de Biotecnologia Animal da FMVZ – UNESP, pela oportunidade de oferecer a vaga para doutorado a mim e aos demais alunos.

A engenheira agrônoma Juliana Gadum de Lalla pelo apoio estatístico. A amiga e colega Beatriz Lippe de Camillo pela grande ajuda na organização das tabelas e análise dos resultados estatísticos e a colega Alessandra Regina Dhom Pimentel de Moraes no auxílio da elaboração das publicações científicas.

Aos colegas André A. T. A, Carrascoza, Leonardo Pereira, Daniel da Silva Penachio, Ana Paula Zancan, Maurício Copelli Zambon, Gerson Acedo Vieira, Vanessa Ribeiro Cruz e Henrique Pinto Lima Garcia e ao treinador João Gabriel Costa, meu agradecimento pela ajuda na disponibilização dos equinos.

Ao amigo Orlando Nagao pela captação das lindas fotografias.

Ao colega e amigo Guilherme Maia Mulder Van de Graaf pela disponibilização do tempo, do equipamento e do auxílio intelectual e físico no desenvolvimento do trabalho, desde o projeto inicial, até o final das avaliações.

A colega Paula Keiko Anadão Tokawa pelo apoio na metodologia e avaliação das imagens.

A minha mãe, Therezinha e aos meus filhos Bruna e Ângelo, pelo carinho, amor, respeito, abraços apertados, que me deram entusiasmo e acolhimento. Para vocês todo o meu amor e orgulho da família da qual fazemos parte.

A amada namorada Gabriela Duarte da Silva, par inseparável, pela tolerância, pelo abraço, pelo carinho, pelo sorriso, pelo acolhimento, pelo prestígio e pela confiança. Seu apoio foi de suma importância. Você é uma pessoa adorável, criativa e encantadora. Sou seu admirador eterno.

AGRADECIMENTO ESPECIAL A CAPES

O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001.

ACKNOWLEDGMENTS

“This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001”.

In Memoriam

Em memória de minha saudosa esposa, Eliane Verzili Gallo, sem palavras para pronunciar, além das saudades, a lacuna na minha existência. Dedico as palavras abaixo, por mim traduzidas de uma canção:

Dias solitários são longos
Crepúsculo canta a felicidade da qual me acostumei
Logo meus olhos fecharão
Em breve encontrarei repouso
Em meus sonhos tu estás sempre ao meu lado
Vejo-te em meus sonhos
E neles eu vou te segurar
Alguém te afastou dos meus braços
Ainda sinto a emoção de teus encantos
Lábios que outrora foram meus
Olhos macios que brilham
Iluminarão o meu caminho nesta noite
Vejo-te em meus sonhos

Extrato da canção*: “I’ll see You in My Dreams”*, de Gustav Gerson Kahn

LISTA DE FIGURAS

LISTA DE TABELAS (*TABLES*)

Table 7 Classification of radiographic findings compatible with KSS in the TB group for both evaluators, at the first moment (M1). The intervertebral space (IVS TB), evaluator 1 (EV1) and evaluator 2 (EV2) and grades 1 to 4, at the first moment 1.

Table 8 Classification of radiographic findings compatible with KSS in the group of TB horses for both evaluators at the second moment (M2). The intervertebral space (IVS TB), evaluator 1 (EV1) and evaluator 2 (EV2) and grades 1 to 4, at second moment 2.

LISTA DE SIGLAS E ABREVIAÇÕES

Arabian Horse: Arab

DR: *Direct Radiography*

Kilovolts power: kVp

KSS: *Kissing Spines Syndrome*

Megahertz: MHz

Miliampere-segundos: mAs

PSA: Puro Sangue Árabe

PSI: Puro Sangue Inglês

Thoroughbred: TB

SUMÁRIO

Página

RESUMO

GALLO, M. A. **ESTUDO DA OCORRÊNCIA DE IMPINGIMENTO DE PROCESSOS ESPINHOSOS DE VÉRTEBRAS TORÁCICAS (KISSING SPINES) EM EQUINOS DAS RAÇAS PURO SANGUE INGLÊS E PURO SANGUE ÁRABE**. Botucatu, 2024. 67 p. Tese (Doutorado) – Faculdade de Medicina Veterinária e Zootecnia, Campus de Botucatu, Universidade Estadual Paulista (UNESP).

A coluna vertebral é essencial para o desempenho dos equinos. A dor no dorso compromete os equinos em competição ou reprodução. O segmento torácico é onde a sela do cavaleiro se apoia e que pode gerar dor, a qual deve ser evitada, rapidamente detectada e o prognóstico e tratamento serem prontamente estabelecidos. O impingimento dos processos espinhosos das vértebras torácicas, denominada de *Kissing Spines Syndrome* (KSS) é uma afecção que acomete equinos e causa queda do desempenho. É considerada a principal causa de dor no dorso. Há trabalhos que buscam melhor entender a ocorrência da KSS, levando-se em consideração a idade, o sexo, a raça e a atividade esportiva a qual o equino exerce e os fatores que aumentem o risco do surgimento; entretanto, a causa determinante não está totalmente elucidada. Os métodos imaginológicos rastreiam alterações compatíveis com a KSS; contudo, a correlação entre os achados de imagem e a manifestação clínica necessita ser aprimorada, por meio de estudos mais aprofundados em equinos sintomáticos e assintomáticos. O exame radiográfico é rápido, eficiente, de baixo custo, que o torna ferramenta de grande auxílio para melhor entender as características da KSS. Este trabalho tem o objetivo de estabelecer um critério prático de posicionamento radiográfico para o auxílio diagnóstico da KSS, triar sua ocorrência e medir as distâncias dos espaços interespinhosos de T2 a T18. Em intervalo de seis meses demonstrou-se haver diferenças significativas. As distâncias dos espaços interespinhosos torácicos podem ser utilizadas como referência anatômica.

Palavras-chave: Radiologia; Dor no dorso; Vértebras; Desempenho atlético; Potros.

ABSTRACT

GALLO, M. A. **STUDY OF THE OCCURRENCE OF IMPINGEMENT OF SPINOUS PROCESSES OF THORACIC VERTEBRAE (KISSING SPINES) IN THOROUGHBREDS AND PUREBRED ARABIAN HORSES**. Botucatu, 2024. 67 p. Thesis (PhD) – São Paulo State University (UNESP), Botucatu, SP, Brazil.

The spine is essential for the performance of horses. Back pain can compromise horses in competition or reproduction. The thoracolumbar segment is the region where the rider's saddle rests and which can generate pain, which must be avoided, quickly detected and the prognosis and treatment be promptly established. Impingement of the spinous processes of the thoracic vertebrae, classically called Kissing Spines Syndrome (KSS), is a condition that affects horses, responsible for a decrease in efficiency and considered the main cause of back pain. There are studies that seek to better understand its occurrence, considering the age, sex, breed and sporting activity in which the horse takes part and the factors that increase the risk of the emergence of KSS; however, the determining cause has not already been fully elucidated. Imaging methods seek to track changes compatible with KSS; however, the correlation between imaging findings and clinical manifestation needs to be improved through more in-depth studies in symptomatic and asymptomatic horses. The radiological examination is fast, efficient and low-cost, and is accessible to equine clinicians, which makes it a very helpful tool to better understand the characteristics of KSS. This work aims to establish a practical radiographic positioning criterion to aid diagnosis of KSS, screen its occurrence and measure the spaces between T2 and T18 at six-month intervals demonstrated that there are significant differences between some spaces. The interspinous distances between T2 and T18 can be used as an average distance reference for horses.

Keywords: Radiology; Back pain; Vertebrae; Performance; Foals.

CAPÍTULO 1

1. INTRODUÇÃO

A dor no dorso dos equinos é motivo comum de queixa do proprietário ou treinador, pela queda do rendimento (M. ZIMMERMAN; S. DYSON; R. MURRAY, 2011; ROSA L. P.; WHITAKER B.; ALLEN K.; PETERS D.; BUCHANAN B.; Mc CLURE S.; HONNASF C.; BUCHNAN C.; MARTIN K.; LUNDQUIST E.; VIERRA M.; FOSTER G.; BROOKS S. A.; LAFAYETTE C., 2022).

O diagnóstico da causa da dor no dorso dos equinos converte-se em tarefa de difícil realização na rotina pela grande espessura da região anatômica, onde a avaliação por imagem se torna um procedimento desafiador (C. ERICHSEN; P. EKSELL; K. ROETHLISBERGER HOLM; P. LORD; C. JOHNSTON, 2004; M. ZIMMERMAN; S. DYSON; R. MURRAY, 2011).

Um dos primeiros relatos com informações detalhadas sobre os aspectos radiográficos da coluna vertebral em equinos foi publicado nos anos 1970 (JEFFCOT, L. B., 1979) citado por outros, que adicionaram detalhes anatômicos com a imagem digital (BUTLER, J. A., COLLES, C., DYSON, S.; KOLD, S.; POULOS, P., 2016; MANSO-DÍAZ, G.; ROMÁN, J., L, S.; WELLER, R., 2018).

A lombalgia preocupa os profissionais da equinocultura, pelas limitações ao desempenho, preocupação com os exames de sanidade em concursos hípicos ou provas de corrida, nos exames de pré-compra e finalmente por causar desconforto e impactar o bem-estar dos equinos (C. ERICHSEN; P. EKSELL; K. ROETHLISBERGER HOLM; P. LORD; C. JOHNSTON, 2004; ALVES, A. L. G.; FONSECA B. P. A., THOMASSIAN A.; NICOLETTI. J. L. M.; HUSSNI, C. A.; SILVEIRA, A., 2007; FONSECA B. P. A.; ALVES, A. L. G.; HUSSNI, C. A., 2011; M. ZIMMERMAN; S. DYSON; R. MURRAY, 2011; PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F., 2023).

O impingimento de processos espinhosos vertebrais ou *Kissing Spine Syndrome* (KSS) é uma afecção que chama o interesse dos médicos veterinários, quanto à localização da dor, pela causa do baixo rendimento esportivo, no bem-estar e saúde geral e, por fim, em detectar fatores de risco em animais assintomáticos a desenvolverem sinais e sintomas clínicos da KSS (M. ZIMMERMAN; S. DYSON; R. MURRAY, 2011; PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F., 2023).

Nos processos espinhosos de vértebras da região torácica nos equinos de esporte podem-se encontrar alterações anatômicas, que são percebidas no exame radiográfico ou pelo exame de cintilografia (ZIMMERMAN M.; DYSON S.; MURRAY R., 2011).

As alterações morfológicas ou de posicionamento dos processos espinhosos podem causar dor e são responsáveis por perdas econômicas no tratamento e no descarte de equinos da sua função (PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F., 2023).

O impingimento ou aglomeração dos processos espinhosos, a sobreposição desses processos, além de fraturas ou malformações são achados observados em exames de imagem de equinos da raça Puro Sangue Inglês (PSI) na Inglaterra (JEFFCOT, L. B., 1979; SINDING M. F.; BERG L. G., 2010).

Entretanto, a correlação entre os achados em exames de imagem e as manifestações clínicas como causa específica da dor no dorso e ou na queda na atividade atlética torna-se uma tarefa árdua, além de muito desafiadora, mesmo para um profissional experiente no diagnóstico clínico e avaliação das imagens obtidas (INFANTEA D.; CROXATTOB A.; CORREA F., 2017)

A disparidade entre os achados radiográficos e os sinais clínicos da KSS torna o seu diagnóstico ainda mais difícil (SINDING M. F.; BERG L. G., 2010).

A equinocultura selecionou equinos pelo desempenho desportivo e para o lazer, que podem sofrer claudicação de origem desconhecida durante sua atividade e que tem como causa dor no dorso, em face à demanda competitiva, permeada por críticas das redes sociais quanto a promover o bem-estar animal (DOMANSKA-KRUPPA, N; WIERZBICKA, M.; STEFANIK, 2024).

2. REVISÃO DE LITERATURA

2.1. Anatomia do dorso equino

O tórax é a parte do tronco dos animais entre a região cervical e o abdômen. Como limites anatômicos pode-se considerar como cranial os músculos formadores da parede torácica, como o músculo subclávio, músculos serrátil ventral, músculos intercostais, músculos reto torácico e transverso do tórax, além de outros, fáscias, vasos sanguíneos e linfáticos, nervos, tecido subcutâneo com músculos subcutâneos e a pele com abundância de pelos, glândulas sebáceas e sudoríparas compõem a camada mais externa da parede torácica e no plano dorsal a crina (KÖNIG H.E., LIEBICH, H-G., 2016).

Os componentes ósseos do tórax formam a caixa torácica, composta dorsalmente por 18 vértebras torácicas, lateralmente por 36 costelas (18 pares) e ventralmente pelo esterno. Os ossos se unem funcionalmente por ligamentos, articulações condrais e verdadeiras. A caixa torácica circunda a cavidade torácica, que é mantida por pressão mecânica de músculos que a compõem (KÖNIG H.E., LIEBICH, H-G., 2016).

O tórax dos equinos tem o formato de um cone achatado lateralmente, onde o seu ápice é voltado para a cabeça e sua base voltada para a cauda (KÖNIG H.E., LIEBICH, H-G., 2016).

A coluna vertebral no dorso é composta por 18 vértebras torácicas, sendo T1 a primeira torácica, que compõe a transição cervicotorácica entre C7-T1, até a transição toracolombar entre T18-L1 (KÖNIG H.E., LIEBICH, H-G., 2016).

As vértebras torácicas têm um processo espinhoso longo no plano mediano, assim como dois processos transversos curtos e possuem facetas articulares para a articulação com as costelas, bilateralmente. O corpo vertebral tem um formato retangular em vista lateral. Cada vértebra torácica se articula com duas vértebras, uma cranial e outra caudal a ela, por meio de dois tipos de articulações (KÖNIG H.E., LIEBICH, H-G., 2016).

A sínfise intervertebral é a articulação cartilaginosa, onde o disco intervertebral é interposto para intensificar a junção, situada ventralmente ao canal vertebral (KÖNIG H.E., LIEBICH, H-G., 2016).

As outras articulações são sinoviais e que permitem os movimentos de lateralidade, de leve rotação, flexão e extensão do dorso e estão situadas dorsalmente ao canal vertebral (SCHULTZ, R. M; ELBRØND, V. S., 2018).

2.2. Desenvolvimento ósseo vertebral

O crescimento ósseo dos equinos cessa aos dois anos ao atingirem a maturidade musculoesquelética, quando são designados à atividade atlética, o que evita o esforço físico precoce e promove a preservação do bem-estar e longevidade. Nesta idade atingem o pico do crescimento ósseo, o fechamento dos discos de crescimento e outros índices como a proporção comprimento do costado e altura de cernelha e comprimento dos membros e altura da região interescapular (ROGERS, C.; GEE, E. K.; DITTMER, K. E., 2021).

As vértebras se desenvolvem pelo crescimento ósseo endocondral. Cada corpo vertebral é composto pelo segmento caudal de um esclerótomo e pelo segmento cranial do esclerótomo adjacente, formado por um modelo de cartilagem do corpo vertebral; portanto, o corpo vertebral é composto por três centros de ossificação primários, um ao centro e um para cada arco vertebral. (ROGERS, C.; GEE, E. K.; DITTMER, K. E., 2021).

A altura da região interescapular apresenta uma curva de crescimento de formato sigmoide. Um potro ao nascer tem aproximadamente 60% da altura máxima. Aos 24 meses terá quase duplicado de altura, do qual parte do crescimento longitudinal ocorre na região proximal dos membros e no tórax (ROGERS, C.; GEE, E. K.; DITTMER, K. E., 2021).

Em estudos feitos com equinos PSI em crescimento concluíram que aos dois anos eles atingem aproximadamente 96% do seu peso corpóreo adulto (ROGERS, C.; GEE, E. K.; DITTMER, K. E., 2021).

Para os equinos, a altura máxima da região interescapular é determinada principalmente pelo crescimento vertebral, do que pelos membros locomotores (ROGERS, C.; GEE, E. K.; DITTMER, K. E., 2021).

2.3. Técnicas e projeções radiográficas

O equino deve estar aprumado em estação com apoio quadrupedal, com o corpo em equilíbrio, a coluna alinhada com a cabeça em posição neutra. Qualquer rotação do eixo da coluna deve ser evitada por alterar o posicionamento anatômico vertebral por ação dos ligamentos nucal e interespinhoso (BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS, P., 2016; MANSO-DÍAZ, G.; ROMÁN, J., L, S.; WELLER, R., 2018).

Quando necessário, deve-se realizar a sedação do animal com zelo no posicionamento já descrito em relação ao apoio dos membros e à posição da cabeça e pescoço (BERNER D.; WINTER K.; BREHM W.; GERLACH K., 2012; BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS, P., 2016).

A acessibilidade do estudo radiográfico da coluna vertebral no segmento torácico dos equinos se tornou um procedimento de rotina e se intensificou com o sistema digital DR (JOHNS, S; ALLEN, A. K.; TYRRELL, L. A., 2008).

Para o estudo radiográfico da região da coluna, podem ser utilizados emissores de Raios X de alta potência na faixa de 150 kVp e 500 mA (JOHNS, S; ALLEN, A. K.; TYRRELL, L. A., 2008; BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS, P., 2016).

Outros trabalhos demonstraram a possibilidade de realizar o mesmo procedimento com equipamentos emissores portáteis de Raios X, o que permite facilidades no transporte e posicionamento, tanto em ambiente hospitalar, quanto a campo. Os fatores de exposição empregados nestes estudos foram menores do que propostos por autores que utilizaram equipamentos fixos ou móveis de maior potência, como os realizados com peças anatômicas de cadáveres, por reduzir a distância entre o foco e a placa digital (SINDING M. F.; BERG L. G., 2010; DJERNÆS J. D.; NIELSEN J. V.; BERG L. C., 2016).

2.4. Anatomia radiográfica das vértebras torácicas

Radiograficamente podem-se identificar nos cavalos adultos 18 vértebras torácicas, de T1 a T18 e os corpos vertebrais com formato aproximadamente retangular, com a cabeça vertebral convexa e a fossa vertebral côncava. Devida a grande massa muscular que envolve a região do dorso, o canal vertebral pode ser visto por subtração exercida pelo ar dos pulmões (JEFFCOT, L. B., 1979; BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS., 2018; MANSO-DÍAZ, G.; ROMÁN, J., L, S.; WELLER, R., 2018).

O processo espinhoso da T1 tem formato triangular e é encurtado em relação à T2 e as demais. O processo espinhoso da T2 é evidentemente mais curto que o da T3 e mais retangular que o da T1. A T1 não possui um diferente centro de ossificação. A T2 até T7 ou T8 possuem um centro de ossificação secundário, simples ou duplo na região mais dorsal (BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS., 2018).

Em potros por volta dos 12 meses de idade e os de sobreano começa a ocorrer a calcificação dos centros de ossificação nas extremidades dorsais dos processos espinhosos, onde os centros de ossificação da T2 até a T6 podem estar presentes em cavalos até os 15 anos (JEFFCOT, L. B., 1979).

As vértebras se orientam dorsalmente em ligeira inclinação caudal. As que possuem processos mais altos são a T6 ou T7 na cernelha (JEFFCOT, L. B., 1979; BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS., 2018).

O ligamento nucal se adere aos ápices dorsais da T2 até T7. A bursa supraespinhosa se situa em T2 e T3, com espaço interespinhoso largo na região interescapular (JEFFCOT, L. B., 1979; KÖNIG H.E., LIEBICH, H-G., 2016).

A vértebra anticlinal nos equinos é a T15, onde o seu processo espinhoso tem um posicionamento vertical e as demais caudais a ela têm seus processos espinhosos mais largos, mais curtos e possuem seu ápice dorsal ligeiramente voltados cranialmente. O espaço interespinhoso se torna bem mais estreito após T9, sendo ainda mais estreito após a T15 no sentido caudal, onde alguns equinos tem o impingimento ou agrupamento dos processos espinhosos (JEFFCOT, L. B., 1979; KÖNIG H.E., LIEBICH, H-G., 2016).

Em equinos de maior porte pode-se constatar haver variação anatômica, onde a vértebra anticlinal é a T16, em um estudo *post-mortem* em diversas raças de equinos de esporte, que vieram a óbito e que tinham no histórico clínico o relato de dor lombar (CLAYTON, H. M.; STUBBSB N. C., 2016).

2.5. Indicações para o estudo radiográfico do dorso

Atualmente o exame radiográfico do dorso dos equinos é feito na rotina, sem dificuldades (MANSO-DÍAZ, G.; ROMÁN, J., L, S.; WELLER, R., 2018).

O surgimento do equipamento DR (*Direct Radiograph*) incrementou a qualidade das imagens obtidas, tornando mais acessível o exame, se comparado ao sistema convencional mais antigo, que por muitas vezes desencorajava a obtenção de diagnóstico radiográfico, devida a grande espessura da região. (JOHNS, S; ALLEN, A. K.; TYRRELL, L. A., 2008).

O estudo radiográfico do dorso em equinos adultos por meio de aparelho emissor de Raios X portátil pode ser realizado de forma eficaz (PIGÉ, C., MASSEAU, I.; BONILHA, A. G., 2020).

O exame radiográfico do dorso é indicado pela manifestação clínica de dor no dorso e diminuição do rendimento atlético ou em exames pré-compra, onde a comparação com sinais clínicos de dor no dorso não foi reportada, o que pode implicar em conclusões conflitantes, quanto a importância de achados, como o impingimento e o agrupamento dos processos espinhosos no segmento toracolombar ou *Kissing Spines Syndrom*e (M. F. SINDING; L. C. BERG. 2010; D. BERNER; K. WINTER; W. BREHM; K. GERLACH, 2012).

Outras indicações além da KSS para se radiografar a coluna são dor no costado e contraturas musculares, trauma na região toracolombar, ataxia e deambulação anormal, resposta positiva em analgesia local, claudicação de membro pélvico não localizada em outra região dos membros, nem por analgesia, ou ainda nos casos os quais o equino apresentou sinal positivo no exame de cintilografia, que sugere patologia em região toracolombar ou até em animais com queda do rendimento ou com relutância a realizar exercícios de equitação (MANSO-DÍAZ, G.; ROMÁN, J., L, S.; WELLER, R., 2018).

2.6. Alterações radiográficas compatíveis com KSS

Muito tem-se estudado sobre os achados radiográficos presentes na KSS. Dentre os autores, os principais achados descritos são esclerose óssea na margem cranial ou caudal dos processos espinhosos, áreas radiolucentes nas mesmas áreas, variação na morfologia usual dos processos espinhosos, normalmente secundárias a reações periosteais ou entesofitos e os achados mais significativos, que são o estreitamento da distância, o toque (impingimento) e a transposição dos processos espinhosos (JEFFCOT, L. B., 1979; ERICHSEN C.; EKSELL P.; HOLM K. R.; LORD P.; JOHNSTON C., 2004, ROSS, M. W.; DYSON, S. J., 2010, INFANTEA D.; CROXATTOB A.; CORREA F., 2017, ZIMMERMAN M.; DYSON S.; MURRAY R., 2011; PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F., 2023).

Em estudo prospectivo pode-se perceber que potros de sobreano da raça PSI antes de iniciarem o treinamento obtiveram alterações vertebrais semelhantes aos equinos mais velhos já em treinamento, o que demonstrou neste estudo haver influência predominante do desenvolvimento na ocorrência precoce da KSS (PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F., 2023).

Outros achados podem estar presentes, de forma incidental, porém sem serem considerados como característicos da KSS, como malformações congênitas e fraturas ou qualquer outro achado que possa demonstrar alteração anatômica da região torácica da coluna vertebral (JEFFCOT, L. B., 1979, BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS., 2018).

2.7. Exame ultrassonográfico do dorso equino

A ultrassonografia é um método auxiliar de diagnóstico na clínica de equinos de esporte, que apresentam claudicação e dor no dorso. Em estudo retrospectivo realizado no *Centre of Equine Studies of Animal Health Trust*, na Inglaterra, realizou-se 39 avaliações ultrassonográficas, dentre um total de 604 equinos, que foram encaminhados com evidências clínicas de dor no dorso, baixo desempenho atlético, comportamento indócil e que o ginete relatou que o cavalo possuía dor lombar. Neste estudo, foram encontradas lesões do ligamento supraespinhoso em 12 animais (83%) dos que apresentaram dor na região toracolombar. Em três animais (25%) com desmite do ligamento supraespinhoso, apresentaram evidência radiográfica de remodelamento ósseo nos aspectos cranial ou dorsal de processos espinhosos (ZIMMERMAN M.; DYSON S.; MURRAY R., 2011a).

O exame ultrassonográfico da coluna integra o protocolo de exame complementar de rotina da coluna vertebral e é bastante sensível na detecção de alterações que acometem os ligamentos supraespinhoso e interespinhoso, os músculos mais dorsais da região, além da avaliação dos processos espinhosos e de suas faces articulares intervertebrais (DOMANSKA-KRUPPA, N; WIERZBICKA, M.; STEFANIK, E., 2024).

Problemas de coluna relativos às partes moles podem ser criteriosamente diagnosticados utilizando-se transdutores de 2,5 a 7,5 MHz. Quando o transdutor é sobreposto à linha mediana da coluna deve-se considerar que algumas variações da ecogenicidade normais podem ocorrer, devido ao fato de que a posição da cabeça do cavalo pode variar durante o exame e pode interferir a ecogenicidade do ligamento, já que sua estrutura elástica pode gerar sinais de eco hipoecogênicos, por conta do relaxamento ligamentar (DOMANSKA-KRUPPA, N; WIERZBICKA, M.; STEFANIK, E., 2024).

Ao posicionar-se o transdutor convexo de dois a quatro centímetros em região paramediana, podem-se observar as faces esquerda e direita dos processos espinhosos, na procura de reações periosteais e de fraturas (DOMANSKA-KRUPPA, N; WIERZBICKA, M.; STEFANIK, E., 2024).

2.8. Fatores de risco para o aparecimento da KSS

O maior fator de risco para a KSS no plantel é a raça, na qual a PSI é a mais prevalente, tanto para os puros, quanto para os cruzados (JEFFCOT, L. B., 1979, ERICHSEN C.; EKSELL P.; HOLM K. R.; LORD P.; JOHNSTON C., 2004, ZIMMERMAN M.; DYSON S.; MURRAY R., 2011a, PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F., 2023).

Em um estudo retrospectivo realizado em potros bem jovens de raças *Warmbloods* concluiu-se um valor mínimo de distanciamento entre os processos espinhosos de quatro milímetros em potros de até três meses de idade e que neste grupo obteve-se ausência de sinais radiográficos precoces de KSS (SINDING M. F.; BERG L. G., 2010).

Em pôneis a ocorrência de achados radiográficos compatíveis com a KSS é considerada nula (JEFFCOT, L. B., 1979).

A maioria dos achados são observados entre T13 e T18, notadamente entre T15 e T16 (INFANTEA D.; CROXATTOB A.; CORREA F., 2017).

2.9. influência da posição da cabeça e pescoço na medida das distâncias entre os processos espinhosos de vértebras torácicas

Foi demonstrado que a extensão da coluna vertebral torácica reduz os espaços entre os processos espinhosos, ao passo que a flexão da mesma região anatômica resulta em aumento dos espaços entre os processos espinhosos, muito bem demonstrado em alguns estudos com animais assintomáticos, onde o efeito de diferentes posições de cabeça e pescoço durante a captação das imagens resultou em variações de distâncias nos referidos espaços (BERNER D.; WINTER K.; BREHM W.; GERLACH K., 2012).

Em um estudo realizado com 23 animais de sexo, raça, porte e atividade equestre distintas e que alguns deles ainda não haviam sido montados foram realizadas radiografias laterolaterais bilateralmente, onde os animais foram radiografados com o ponto focal do emissor nas articulações intervertebrais, demonstrou-se que a altura do conjunto cabeça e pescoço altera as medidas das distâncias entre os processos espinhosos (BERNER D.; WINTER K.; BREHM W.; GERLACH K., 2012).

As três posições propostas foram: intermediária, com a boca na altura do ombro; baixa, com a boca na altura do carpo; e alta, com a boca na altura da cernelha (BERNER D.; WINTER K.; BREHM W.; GERLACH K., 2012).

A distância entre processos espinhosos de T8 a T14 foi significativamente maior na posição baixa, quando comparada às outras duas posições. A distância entre os processos espinhosos de T15 e T16 e entre T16 e T17 foi maior na posição baixa, do que na posição alta. E na posição alta, a distância entre os processos espinhosos de T9, T10, T11, T13 e T17 e seus respectivos caudais foi significativamente menor do que na posição intermediária (BERNER D.; WINTER K.; BREHM W.; GERLACH K., 2012).

2.10. Influência da elevação abdominal nas medidas radiográficas dos espaços interespinhosos

A posição de contração e relaxamento da musculatura abdominal ou do core do equino pode influenciar também na alteração das medidas entre os espaços intercostais.

Foram realizadas radiografias centradas em T13 e T18 aplicando-se diferentes graus de tensão por uma faixa larga sob o abdômen de sete cavalos saudáveis assintomáticos e sedados. Foram medidos os espaços interespinhosos entre T11 e L2, por seguir um método padronizado. Os espaços interespinhosos se alargam radiograficamente entre T11 e L2, exceto T18-L1. Desenvolveu-se esta manobra com o objetivo de afastar os processos espinhosos durante atos cirúrgicos para facilitar a abordagem cirúrgica individual dos processos (PIGÉ, C.; MASSEAU BONILHA, A. G, I., 2020).

2.11. Cintilografia da coluna vertebral

Foi realizado um estudo retrospectivo com animais que foram referendados ao *Centre of Equine Studies of Animal Health Trust*, na Inglaterra, quando foram submetidos a exames radiográficos e cintilográficos 582 equinos, com evidências clínicas de dor no dorso e baixo rendimento esportivo. Por análise estatística realizou-se estudo comparativo entre os achados radiográficos de imagens com alterações compatíveis com KSS, dos achados cintilográficos, que basicamente era a maior captação de radiofármacos nos processos espinhosos vertebrais e os achados combinados radiográficos/cintilográficos e sua relação com equinos, cujos sinais clínicos eram presentes ou ausentes para dor no dorso (ZIMMERMAN M.; DYSON S.; MURRAY R., 2011b).

Neste estudo houve a conclusão de que claudicação e/ou dor dos membros torácicos ou pélvicos associadas às articulações sacroilíacas podem mimetizar a dor toracolombar primária. A combinação do estudo radiográfico e cintilográfico fornece a caracterização mais precisa da dor toracolombar; entretando, a analgesia diagnóstica é crucial para um diagnóstico preciso (ZIMMERMAN M.; DYSON S.; MURRAY R., 2011b).

2.12. KSS no passado

Arqueólogos da Universidade de Wroclaw na Polônia, por escavações em sítios arqueológicos da região geográfica antiga, obtiveram amostra de esqueleto axial de um cavalo denominado “cavalo de Worclaw”, região da Polônia da Europa Central medieval, aproximadamente no século XIV (JANECZEK, M.: CHRÓSZCZ, A; ONAR, A.; HENKLEWSKI, R.; PIEKALSKI, P.; DUMA, P.; CZERSKI, A.; CAŁKOSIŃSKI, I.; 2012).

Esse fragmento de esqueleto foi classificado por analogia morfológica como sendo um segmento de vértebras T11 a L2, as quais dez vértebras recuperadas estavam fusionadas, com sinais avançados de doença articular degenerativa intervertebral, com fusões entre os corpos e arcos vertebrais, mais evidente no lado esquerdo. A estimativa era de ser de um equino de cinco anos de idade, pelo estado de fusão das linhas de crescimento das epífises vertebrais (JANECZEK, M.: CHRÓSZCZ, A; ONAR, A.; HENKLEWSKI, R.; PIEKALSKI, P.; DUMA, P.; CZERSKI, A.; CAŁKOSIŃSKI, I.; 2012).

Na época medieval os equinos daquela região eram utilizados em montaria, na maioria das vezes. Por estudo radiográfico deste fragmento de coluna e pelas imagens foram encontrados sinais avançados de proliferação em inserções de ligamentos intervertebrais, de músculos espinhais, formando pontes ósseas entesofíticas, além de redução e mineralização dos espaços intervertebrais, cujos autores identificaram a KSS em cavalos da era medieval (JANECZEK, M.: CHRÓSZCZ, A; ONAR, A.; HENKLEWSKI, R.; PIEKALSKI, P.; DUMA, P.; CZERSKI, A.; CAŁKOSIŃSKI, I.; 2012).

3. Justificativa

O interesse para este estudo está na importância de triar um grupo de animais com KSS para entender a ocorrência, a precocidade do aparecimento desta síndrome e estabelecer um critério de posicionamento radiográfico e medidas que possam contribuir para o seu diagnóstico na população jovem em fase de doma e nos primeiros meses de trabalho.

Há relato que seis meses de treinamento para equinos jovens, pela biomecânica pode induzir o surgimento da KSS (JEFFCOT, L. B., 1979).

A hipótese inicial baseada em literatura é que há diferença, tanto nas medidas das distâncias entre os processos espinhosos, quanto na ocorrência de evidências radiográficas da KSS entre as raças PSI e PSA.

A escassez de relatos em literatura que envolvem equinos da raça Puro Sangue Árabe (PSA) jovens, antes de iniciarem o programa de treinamento despertou interesse em se comparar ambos os grupos, PSA e PSI.

4. Objetivos

4.1. Objetivos gerais: investigar e caracterizar a KSS sob o ponto de vista radiográfico para os equinos acometidos assintomáticos, notadamente em condições de campo e no início do treinamento, por meio da radiologia digital. Reconhecer outras possíveis alterações radiográficas que também possam estar presentes nos achados da coluna vertebral torácica.

4.2. Objetivos específicos: avaliar pela imagem radiográfica digital se houve ou não o impingimento ou redução dos espaços entre os processos espinhosos entre T2 e T18 entre os dois momentos avaliados, no intervalo de seis meses entre o primeiro dia e o sexto mês pós treinamento para os equinos da raça PSI e em regime de pasto da raça PSA.

Propor um método de adquirir as imagens que possam contribuir para o diagnóstico da KSS e medir as distâncias entre os processos espinhosos por estabelecer um ponto anatômico de referência, como ponto focal adequado e de boa acurácia das análises das imagens radiográficas.

REFERÊNCIAS

ALVES, A. L. G.; FONSECA B. P. A., THOMASSIAN A.; NICOLETTI. J. L. M.; HUSSNI, C. A.; SILVEIRA, A. B. Brazilian Journal of Veterinary Research in Animal Science, São Paulo, v. 44, n. 3, p. 191-199, 2007.

BERNER D.; WINTER K.; BREHM W.; GERLACH K. Influence of head and neck position on radiographic measurement of intervertebral distances between thoracic dorsal spinous processes in clinically sound horses. Equine Veterinary Journal, v. 44, p. 21-26, 2012.

BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS, P. Clinical Radiology of the Horse, Fourth Edition, Blackwell Publishing Company, 2016.

CLAYTON, H. M.; STUBBSB N. C. Enthesophytosis and Impingement of the Dorsal Spinous 2 Processes in the Equine Thoracolumbar Spine. Journal of Equine Veterinary Science. v. 47, p. 9-15, 2016.

DJERNÆS J. D.; NIELSEN J. V.; BERG L. C. Effects of X-ray beam angle and geometric distortion on width of equine thoracolumbar interspinous space using radiography and computed tomography – a cadaveric study. Veterinary Radiology and Ultrassound, v. 00, n. 0, p. 1-7, 2016.

DOMANSKA-KRUPPA, N; WIERZBICKA, M.; STEFANIK, E. Advances in Clinical Diagnostics to Equine Back Pain: A Review of Imaging and Functional Modalities, Animals, MPDI, v. 14, 698, p. 1-16, 2024.

ERICHSEN C.; EKSELL P.; HOLM K. R.; LORD P.; JOHNSTON C. Relationship between scintigraphic and radiographic evaluations of spinous processes in the thoracolumbar spine in riding horses without clinical signs of back problems. Equine Veterinary Journal, v. 36, p.458-465, 2004.

FONSECA B. P. A.; ALVES, A. L. G.; HUSSNI, C. A. Clinical exam protocol for the equine thoracolumbar spine. Brazilian Journal of Veterinary Research in Animal Science, São Paulo, v. 48, n. 4, p. 271-280, 2011.

INFANTEA D.; CROXATTOB A.; CORREA F. Radiologic findings consistent with kissing spines syndrome in Chilean thoroughbreds' horses, Sustainability Agri, Food and Environmental, Researchgate, v. 4, p.14-17 2017.

JANECZEK, M.: CHRÓSZCZ, A; ONAR, A.; HENKLEWSKI, R.; PIEKALSKI, P.; DUMA, P.; CZERSKI, A.; CAŁKOSIŃSKI, I.; Anatomical and Biomechanical Aspects of the Horse Spine: The Interpretation of Vertebral Fusion in a Medieval Horse from Wroclaw (Poland), International Journal of Osteoarchaeology, John Wiley & Sons, Ltd., 2012.

JEFFCOT, L. B. Radiographic Features of the Normal Equine Thoracolumbar Spine. American College of Veterinary Radiology, v. 20, p. 140-147, 1979.

JOHNS, S; ALLEN, A. K.; TYRRELL, L. A. How to Obtain Digital Radiographs of the Thoracolumbar Spine in the Standing Horse. AAEP Proceedings Vol. 54, p. 455-458, 2008.

KÖNIG, H.E.; LIEBICH, H.-G. Anatomia dos animais domésticos: texto e atlas colorido, 6ª ed. Artmed, Porto Alegre, 2016.

MANSO-DÍAZ, G.; ROMÁN, J., L, S.; WELLER, R. A Practical Guide to Equine Radiography, 5M Publishing, 2018.

PIGÉ, C.; MASSEAU, I.; BONILHA, A. G. Influence of abdominal elevation on radiographic measurements of the thoracolumbar interspinous spaces in asymptomatic horses. Canadian Veterinary Journal, v. 61. p. 1101-1105, 2020.

PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F. Radiographic abnormalities of the thoracolumbar spinous processes do not differ between yearling and trained Thoroughbred horses without perceived back pain. Journal of American Veterinary Medicine Association, v. 261, n. 6, p. 844-851, 2023.

ROGERS, C.; GEE, E. K.; DITTMER, K. E. Growth and Bone Development in the Horse: When Is a Horse Skeletally Mature? Animals, MPDI, v. 11, p. 1-14, 2021.

ROSA L. P.; WHITAKER B.; ALLEN K.; PETERS D.; BUCHANAN B.; McCLURE S.; HONNASF C.; BUCHNAN C.; MARTIN K.; LUNDQUIST E.; VIERRA M.; FOSTER G.; BROOKS S. A.; LAFAYETTE C. Genomic loci associated with performance limiting equine overriding spinous processes (kissing spines). Research in Veterinary Science, v.150, p. 65–71, 2022.

ROSS, M. W.; DYSON, S. J. Diagnosis and Management of Lameness in the Horse 2nd Edition, Elsevier Saunders, 2010.

SCHULTZ, R. M; ELBRØND, V. S. Novel dissection approach of equine back muscles: new advances in anatomy and topography - and comparison to present literature. Science Publishing Group Journal. p. 1-13, 2018.

SINDING M. F.; BERG L. G. Distances between thoracic spinous processes in Warmblood foals: A radiographic study. Equine Veterinary Journal, v. 42, n. 6, p. 500-503, 2010.

ZIMMERMAN M.; DYSON S.; MURRAY R. Close, impinging and overriding spinous processes in the thoracolumbar spine: The relationship between radiological and scintigraphic findings and clinical signs. Equine Veterinary Journal, v. 44, p. 178-184, 2011.

ZIMMERMAN M.; DYSON S.; MURRAY R. Comparison of Radiographic and Scintigraphic Findings of the Spinous Processes in the Equine Thoracolumbar Region. Veterinary Radiology and Ultrassound, v. 52, n. 6, p. 661-671, 2011.

CAPÍTULO 2

Trabalho a ser enviado para *Veterinary Radiology & Ultrasound*
Online ISSN: 1740-8261, Print ISSN: 1058-8183
Title: Occurrence of impingement of the spinous processes of the thoracic vertebrae (kissing spines) in Thoroughbreds and Arabian horses

Keywords: Radiology; Back pain; Vertebrae
Running head: Gallo et al. Study of the incidence of impingement of the spinous processes of the thoracic vertebrae of the thoracic vertebrae (kissing spines) in Thoroughbreds and Arabian horses

Marco Aurélio Gallo [1 ID], Alessandra Regina Dhom Pimentel de Moraes [1], Vania Maria de Vasconcelos Machado [1]
1 Department of Animal Reproduction and Veterinary Radiology São Paulo State University (Unesp), Botucatu, SP, BRAZIL

Correspondence
Vania Maria de Vasconcelos Machado, Faculdade de Medicina Veterinária e Zootecnia - Câmpus de Botucatu
Rua Prof. Doutor Walter Mauricio Correa, s/n - Unesp Campus de Botucatu
Botucatu - SP
CEP 18618-681
E-mail: vania.mv.machado@unesp.br

Funding information
São Paulo State University (Unesp), Botucatu, SP, Brazil

Conflict of interest statement.
The authors declare that there are no conflicts of interest

ABSTRACT

Kissing Spines Syndrome (KSS) is a significant problem for young horses at the beginning of training, affecting their performance and health. This study investigated the early onset of KSS in the first six months of training, using digital radiography (DR) to establish diagnostic criteria, comparing the thoracic spines of Thoroughbred (TB) and Arabian (Arab) horses, focusing on the area between T2 and T18, before and after training. The results showed significant differences in measurements between spinal processes, with TB horses showing a higher risk of KSS ($p < 0.05$). Early radiographic screening can greatly assist in the diagnosis and prevention of the syndrome.

INTRODUCTION

Pain in the back of horses is commonly reported by owners or trainers, causing performance failure (1, 2). Diagnosing the cause of pain in the back of horses becomes difficult on a routine basis due to the great thickness of the anatomical region, where imaging assessment becomes a challenging procedure (3, 1). One of the first reports with detailed information on the radiographic aspects of the spinal column in horses was published in the 1970s (4) and complemented by other authors with the advent of digital imaging (5, 6). Diagnosing the cause of pain in the back of horses is a challenging task due to the thickness of the body region, where imaging assessment becomes particularly difficult (3, 7, 8, 1, 9). Impingement of the spinous processes of the thoracic vertebrae, or Kissing Spine Syndrome (KSS), is a condition that draws the interest of sport equine veterinarians regarding the exact anatomical location of pain, due to poor performance, well-being and general health, as well as detecting risk factors in asymptomatic horses developing clinical signs and symptoms of KSS during training (1, 9). However, the correlation between imaging findings and clinical manifestations as a specific cause of back pain or falls during competition becomes an arduous task, posing challenges even for experienced professionals in clinical diagnosis and image evaluation (10). The discrepancy between radiographic findings and clinical signs of KSS further complicates its diagnosis (11).

Equine farming has selected horses for sport and leisure, which may suffer from lameness of unknown origin, including back pain, amidst competitive demands and social media criticism regarding animal welfare (12).
The aim of this study was to establish a practical radiographic positioning criterion to aid in the diagnosis and screening of KSS in young horses, focusing on radiographic findings compatible with KSS and the measurement of interspinous spaces using a digital radiographic approach, comparing Thoroughbreds and Arabians two years old horses during early training.

METHODS

The study included 60 Thoroughbred English horses (TB), 31 females (51.7%) and 29 intact males (48.3%), and 26 Pure Arabians (Arab), 13 females (50%) and 13 intact males (50%), which will compete in endurance events in the future.

At the time of the first image (M1), all horses were 2-y-o, and not already completed three years old. The images were taken between 09/01/2023 and 08/03/2024, while these group of TB and Arab maintain their routine life.

The project was approved by the Ethical Committee for the Use of Animals (CEUA) of the Faculty of Veterinary Medicine and Zootechnics of UNESP, in Botucatu, under protocol 0005/2022, on 19/01/2022.

The minimum total number of 60 animals was determined by considering the degrees of freedom of the residual design to be used, which, according to the literature, should be at least 20 and by considering the possible loss of data (animals) during the project.

Animals were provided after prior contact with the owner or person in charge, who signed the free and informed consent form for clinical studies, explaining the purposes clearly and guaranteeing the confidentiality of the information obtained.

The TB horses were housed at the Sao Paulo Jockey Club, in the city of Sao Paulo and at the Jockey Club Training Center, in Campinas, 90 km further from Sao Paulo city. The purity of the TB breed horses was verified by the Identity Card, issued by the Brazilian Stud Book (SBB) and Brazilian Association of Racehorse Breeders and Owners (ABCPCC). The TB colts had already been tamed to trotting and galloping on the flat track.

The Arab horses were housed at two breeding farms and an endurance training center in the municipality of Bragança Paulista, also 90 km from Sao Paulo city. They were all living in free pasture and were only grouped together for routine procedures such as hoof trimming, deworming and vaccinations. The batches of males and females were different.

The Arab animals used in the study were healthy and lived in stud farms where welfare practices are promoted for the horses housed.

For the Arab horses, all animals were sedated with 1% detomidine hydrochloride administered intravenously into the jugular vein at a dose of 20 to 40 µg/kg. Approximately three minutes after sedation, the animals cooperated with the radiographic examination.

None of the radiographed animals had external signs of spinal lesions in any segment, and none of the radiographed animals had a clinical history of spinal lesions, back pain, decreased performance, motor incoordination, or had undergone local or systemic treatment for pain relief.

One TB female was excluded because she had vestigial multiple fractures of the spinous processes with a chronic aspect that could affect the measurement of the distance between the cranial spinous processes. A total of 59 TB and 26 Arab horses were evaluated.

Two TB animals, one female and one male, part of the group at moment 1 (59 animals) were no longer housed at the Jockey Club at the second moment, which reduced the group (57 animals).

Student's t-test was used to compare measurements between the interspinous spaces from T2 to T18 between the Arab and TB breeds ($P<0.05$).

The shortest distance in millimeters between the caudal cortical bone surface of a spinous process of a cranial vertebra and the cranial surface of its subsequent caudal in a row between T2 and T18 was measured.

The images obtained were evaluated by two experienced professionals after prior training on the parameters to be observed in the images, such as the degree of the findings and the distances of the interspinous spaces.

Secondly, the distance of the same spaces was measured to assess whether there was a difference between the spaces after six months, and the data were submitted to a compatible statistical model for comparative analysis.

The portable X-ray unit used was a JOB (JOB Corporation, Yokohama, Japan) Porta 100 HF model with a power of 40-100 kV/20-30 mAs, a fine focus of 1.2 mm matched with a DR (digital radiography) detector measuring 14 X 17 inches (CareRay Digital Medical Technology Co., Ltd., Suzhou, China).

The exposure factors were adjusted according to the sensitivity of the DR panel and according to the physical size of the animal being evaluated, consisting of the muscle mass covering the vertebrae, the laterolateral thickness, and the thickness of the bone tissue, which are individual anatomical variations. A lower kilovoltage was used in the cranial thoracic region, the withers, than in the caudal thoracic region, the back, due to the greater thickness of the lumbar region.

On average, the technique used on TB horses varied from animal to animal, ranging from 85 to 95 kVp, increasing as the study progressed from cranial to caudal. Milliamperes were used in conjunction with exposure times (mAs) ranging from 1.8 to 6.0 mAs.

The predetermined focal points were the spinous processes of T2, T6, and T12. The T2-weighted image was obtained with the lead attached to the muscle belly of the subclavian muscle, cranially to the proximal end of the scapular spine, to evaluate and study the T2 to T6 segment. The T6-focused image was obtained after some tests where it was observed that the focal point of T6 was the highest part of the withers, which corresponded to the spinous process of T6, to evaluate the segment between T6 and T12, and the T12-focused image, to evaluate the segment between T12 and T18, was obtained with a palpable point at the most cranial beginning of the flattest part of the back, as shown in the Figure 1.

FIGURE 1: Focal points with fishing pellets adhered to palpable anatomical references. In the caudal neck, focus on T2 at the cranial limit of the belly of the subclavian muscle at the withers. Distal to the end of the mane and highest point of the withers, focus for T6. At the beginning of the back flat region is the focus for T12.

The immobility of the horses during the acquisition of the radiographs was considered. The moment of positioning the horse, the stability of the animal on the support was observed, as well as a reduction in the contractile movements of the back muscles and subcutaneous tissues in the anatomical areas of interest to avoid distorted and magnified images that could confuse the evaluator when counting the vertebrae.

The position of the head on the station at neutral height was considered, with the stableman holding the head steady by the halter guide and the lower lip at the same height as the highest point of the withers of the horse he was holding.

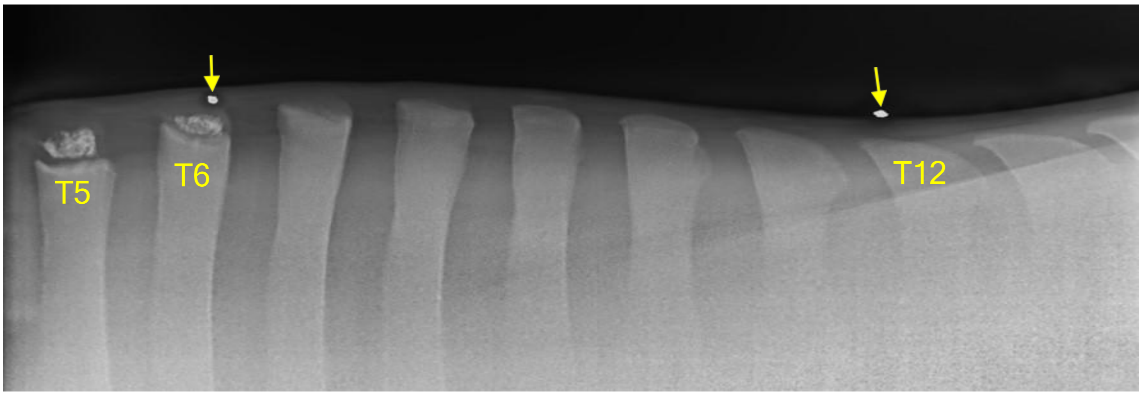

FIGURE 2: Radiograph in laterolateral projection, with the digital panel positioned to the right of the withers of a 2-year-old TB horse. The spinous processes of T6 and T12 (yellow arrows) point to the lead markers. Note the separate ossification centers at the dorsal end of T5 and T6.

Findings compatible with KSS were entered into a spreadsheet according to the criteria of negative (0) for those without signs of KSS or positive, in which case the degree of involvement (1 to 4) was determined based on previous reports, as shown in Table 1 below.

Table 1: Demonstration the Grade with the numerical value from 0 to 4 in the left column and the radiographic findings present for each value found, based on reference authors.

Grade 0	Absence radiographic of KSS findings
Grade 1	Narrowing of IES
Grade 2	Spinous processes touch and slight cortical bone sclerosis
Grade 3	Spinous processes touch, bone modelling and enthesophytes
Grade 4	Advanced bone modelling with lysis and spinous processes touch or overlap

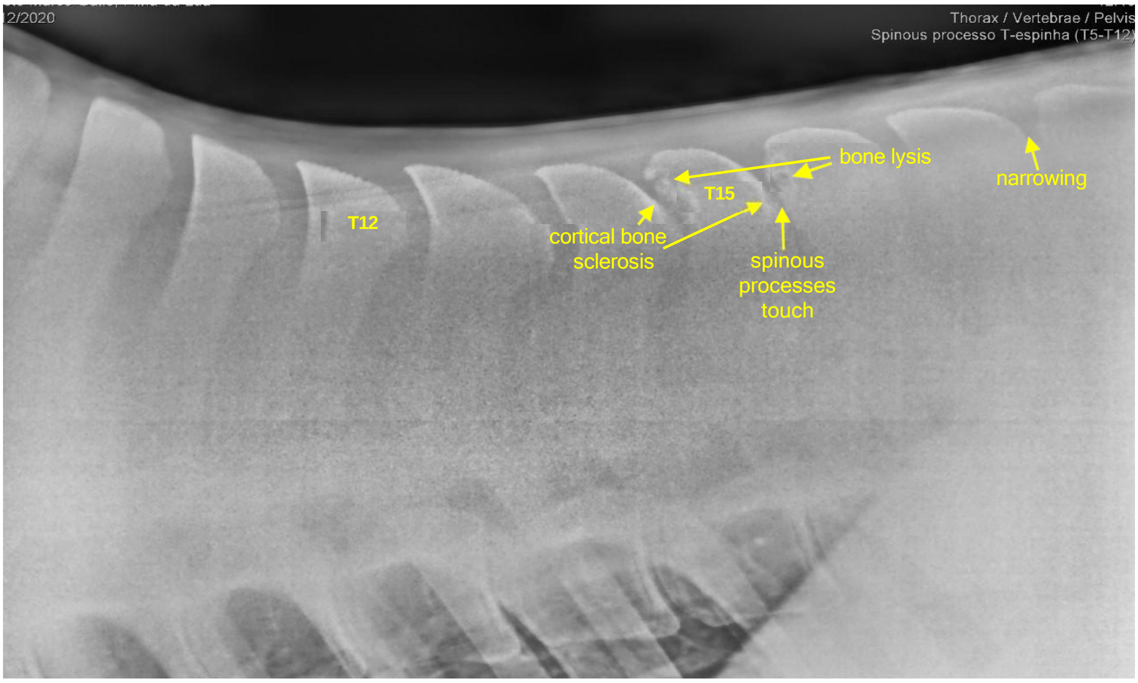

FIGURE 3: Radiograph in laterolateral projection, with the digital panel positioned to the right side of the flat back of a 2-year-old TB horse. The spinous processes of T14 and T15 pointing bone sclerosis, T15 and T16 pointing bone lysis and T17-T18 narrowing of interspinous space.

In another table with the analysis of the same images at both times, the distance between the spinous processes of the thoracic vertebrae between T2 and T18 was measured using the digital system program and the averages per space per breed and between the two times were calculated. The average of each space was determined.

The average of each space was calculated between breeds and time points to see if there were changes between the spaces over the six-month interval.

The values obtained were entered into an Excell spreadsheet and then entered a statistical analysis that evaluated the absolute numerical data for comparison between breeds, between evaluators, and between the two points in time with the same average six-month interval for the horses between the two image acquisitions.

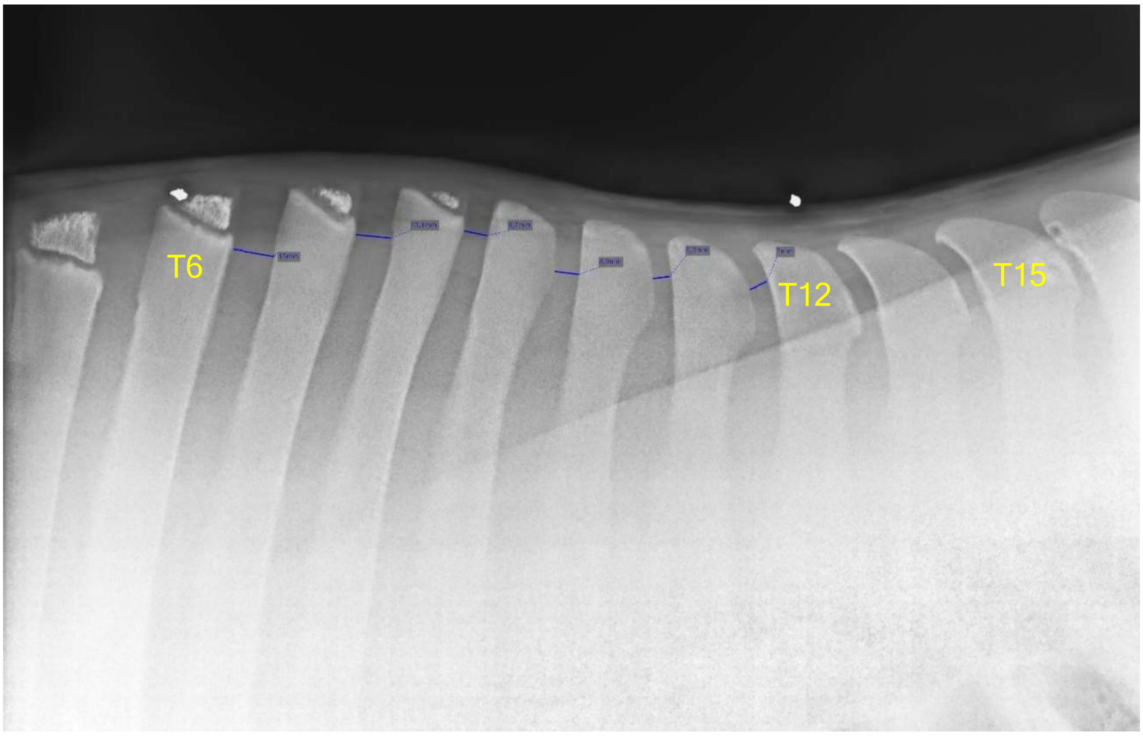

FIGURE 4: Laterolateral radiograph of a 2-year-old TB horse showing spinous processes T5 through T15 with external radiopaque markers at spinous processes T6 and T12. Distance measurements were made using the Digital Panel Viewer program. The caudal cortical surface of T15 shows sclerosis and bone remodeling, and the cranial cortical surface of T16 shows the same characteristics described with osteolysis (yellow arrow). The distance between T15 and T16 is reduced. This animal was scored grade 4.

RESULTS

There was a statistically significant difference in the measurements of the distances between the interspinous spaces for the first evaluator (EV1) between the Arab and TB races at the first moment (M1) between spaces T2-T3; T3-T4; T4-T5; T12-T13; T13-T14; T14-T15; T15-T16 and T16-T17. There was no statistically significant difference between rooms T5 to T12 and T17-T18.

There was a statistically significant difference in the measurements of the interspinous processes distances for the first evaluator (EV1) between the Arab and TB breeds at the second moment (M2) between the spaces T2-T3; T3-T4; T4-T5; T5-T6; T12-T13; T13-T14; T14-T15; T15-T16 and T16-T17.

There was no statistically significant difference between the rooms from T6 to T12 and T17-T18. The results of evaluator 1 (EV1) at Time 1 (M1EV1) and moment 2 (M2EV1) are shown in Table 2, with measurements in millimeters for the interspinous spaces:

TABLE 2: Measurements interspinous distance in each intervertebral space (IVS) by evaluator 1 at moments 1 (M1EV1) and 2 (M2EV1) in the Arab and TB breeds:

	M1EV1			M2EV1		
IVS	Arab	TB	p	Arab	TB	P
T2-T3	14,5 ± 3,0	10,4 ± 2,9	< 0,001	15,3 ± 2,7	11,1 ± 3,3	< 0,001
T3-T4	11,9 ± 1,7	8,7 ± 2,3	< 0,001	12,0 ± 1,6	8,9 ± 2,3	< 0,001
T4-T5	13,1 ± 3,0	10,6 ± 2,7	< 0,001	13,7 ± 2,7	10,7 ± 2,9	< 0,001
T5-T6	15,1 ± 2,6	13,7 ± 2,9	= 0,026	16,7 ± 2,2	14,2 ± 2,9	< 0,001
T6-T7	15,9 ± 2,7	15,5 ± 2,6	= 0,599	18,1 ± 2,3	16,6 ± 2,6	= 0,011
T7-T8	14,4 ± 2,7	14,5 ± 2,8	= 0,858	16,1 ± 2,0	14,9 ± 2,8	= 0,039
T8-T9	12,8 ± 2,6	11,8 ± 2,2	= 0,080	13,7 ± 2,1	12,1 ± 2,5	= 0,007
T9-T10	11,0 ± 3,3	10,6 ± 2,2	= 0,440	11,5 ± 2,7	10,3 ± 2,6	= 0,053
T10-T11	8,7 ± 3,4	8,0 ± 2,1	= 0,265	8,7 ± 3,1	7,9 ± 2,0	= 0,175
T11-T12	8,3 ± 2,6	6,5 ± 2,5	= 0,005	8,0 ± 2,3	6,1 ± 2,8	= 0,003
T12-T13	7,7 ± 1,9	5,4 ± 2,4	< 0,001	7,4 ± 1,7	5,3 ± 2,7	< 0,001
T13-T14	6,1 ± 2,0	3,5 ± 2,4	< 0,001	5,7 ± 1,9	3,0 ± 2,3	< 0,001
T14-T15	5,0 ± 1,5	2,8 ± 2,0	< 0,001	5,0 ± 1,6	2,2 ± 1,7	< 0,001
T15-T16	5,3 ± 2,1	2,9 ± 2,1	< 0,001	5,3 ± 2,0	2,6 ± 2,0	< 0,001
T16-T17	5,4 ± 1,5	3,0 ± 2,4	< 0,001	5,5 ± 1,9	3,0 ± 2,7	< 0,001
T17-T18	5,8 ± 2,3	4,3 ± 2,5	= 0,015	5,9 ± 2,5	4,0 ± 3,3	= 0,010

There was a statistically significant difference in the interspinous space measurements for the second evaluator (EV2) between the Arab and TB races at the first moment (M1) between spaces T2-T3; T3-T4; T4-T5; T5-T6; T11-T12; T12-T13; T13-T14; T14-T15; T15-T16 and T16-T17. There was no statistical difference between the distances from T6 to T11 and T17-T18.

The results of evaluator 2 at moment 1 (M1EV2) and moment 2 (M2EV2) are shown in Table 3, with measurements in millimeters for the interspinous processes distances:

TABLE 3: Measurements of each interspinous spaces (ISS) by evaluator 2 at moments 1 (M1EV2) and 2 (M2EV2) in the Arab and TB breeds:

	M1EV2			M2EV2		
ISS	**Arab**	**TB**	**P**	**Arab**	**TB**	**P**
T2-T3	14,2 ± 2,9	9,7 ± 3,3	< 0,001	14,2 ± 2,8	9,0 ± 3,4	< 0,001
T3-T4	11,1 ± 1,7	8,1 ± 2,3	< 0,001	11,6 ± 1,5	8,2 ± 2,3	< 0,001
T4-T5	13,0 ± 3,0	10,0 ± 3,4	< 0,001	13,2 ± 2,7	10,1 ± 3,1	< 0,001
T5-T6	15,1 ± 2,6	12,3 ± 3,8	< 0,001	16,3 ± 2,4	13,6 ± 3,3	< 0,001
T6-T7	16,0 ± 2,9	15,1 ± 4,0	= 0,283	17,4 ± 2,9	16,4 ± 3,7	= 0,223
T7-T8	14,1 ± 2,6	13,0 ± 3,9	= 0,196	15,6 ± 2,1	14,8 ± 2,4	= 0,169
T8-T9	12,3 ± 2,5	10,5 ± 3,0	= 0,016	13,2 ± 2,2	11,9 ± 2,3	= 0,014
T9-T10	10,6 ± 3,3	9,8 ± 2,3	= 0,196	10,8 ± 2,6	10,3 ± 2,2	= 0,361
T10-T11	8,50 ± 3,1	7,8 ± 1,9	= 0,174	8,3 ± 3,0	8,1 ± 1,9	= 0,776
T11-T12	8,7 ± 3,0	6,5 ± 2,5	< 0,001	8,0 ± 2,3	6,3 ± 2,8	= 0,012
T12-T13	7,8 ± 2,2	5,3 ± 3,0	< 0,001	7,0 ± 2,4	5,3 ± 2,8	= 0,011
T13-T14	6,0 ± 1,8	3,1 ± 3,0	< 0,001	5,5 ± 2,3	3,0 ± 2,5	< 0,001
T14-T15	5,1 ± 1,7	2,6 ± 2,5	< 0,001	4,6 ± 1,9	2,3 ± 2,9	< 0,001
T15-T16	5,0 ± 2,0	2,5 ± 2,0	< 0,001	4,9 ± 2,1	2,3 ± 2,3	< 0,001
T16-T17	5,0 ± 1,8	2,6 ± 2,4	< 0,001	5,4 ± 2,0	2,6 ± 2,5	< 0,001
T17-T18	5,6 ± 2,3	3,5 ± 2,9	= 0,002	5,6 ± 2,5	3,4 ± 3,1	= 0,002

The spaces with statistically different measurements between moments M1 and M2 for evaluator AV2 were T11-T12 and T12-T13.

The one-way repeated measures t-test (P<0.05) was used to compare the interspinous space measurements at the two evaluation moments, separately for each breed and for each evaluator.

There was a statistically significant difference between moments 1 and 2 (P<0.050) for the measurement of distances between T5-T6 (P=0.018), T6-T7 (P=0.001) and T7-T8 (P=0.002) for Arab horses, for evaluator 1 and there was no statistically significant difference between T2-T4 (P=0.042), T5-T6 (P=0.004), T6-T7 (0.0060) and T7-T8 (0.003) for evaluator 2.

There was no difference between moments 1 and 2 for the evaluator 1 for interspinous space distance: T2-T3 (P = 0.243); T3-T4 (P = 0.341); T4-T5 (P = 0.383); T8-T9 (P = 0.131); T9-T10 (P = 0.540); T10-T11 (P = 0.944); T11-T12 (P = 0. 758); T12- T13 (P = 0.575); T13-T14 (P = 0.530); T14-T15 (P = 0.844); T15-T16 (P = 0.904); T16-T17 (P = 0.758) and T17-T18 (P = 0. 900) and for evaluator

2 for the distance between the spaces T2-T3 (=0.932); T4-T5 (=0.487); T8-T9 (=0.053); T9-T10 (=0.618); T10-T11 (=0. 629); T11-T12 (=0.061); T12-T13 (=0.018); T13-T14 (=0.151); T14-T15 (=0.034); T15-T16 (=0.312); T16-T17 (0.0134) and T17-T18 (=0.660) for Arab horses.

For horses of TB breed between moments 1 and 2 and there was no statistically significant difference between the moments in the measurements of the interspinous spaces T2-T3 (P = 0,372); T3-T4 (P = 0,522); T4-T5 (P = 0,980); T5-T6 (P = 0,374); T6-T7 (=0,075); T7-T8 (P = 0,495); T8-T9 (P = 0,567); T9-T10 (P = 0,533); T10-T11 (P = 0,877); T11-T12 (P = 0,506); T12-T13 (P = 0,973); T13-T14 (P = 0,400); T14-T15 (P = 0,166); T15-T16 (P = 0,477); T16-T17 (P = 0,956) e T17-T18 (P = 0,510) for the evaluator 1.

There was a statistically significant difference (P<0.05) for the group of TB horses between moments 1 and 2, for evaluator 2, in spaces T5-T6 (P=0.047); T7-T8 (P=0.003) and T8-T9 (P=0.021) and there was no statistically significant difference between spaces T2-T3 (P=0.255); T3-T4 (P=0.860); T4-T5 (P=0.716); T6-T7 (P=0.068); T9-T10 (P=0.206); T10-T11 (P=0.283); T11-T12 (P=0.857); T12-T13 (P=0.994); T13-T14 (P=0.651); T14-T15 (P=0.415); T15-T16 (P=0.455) and T16-T17 (P=0.640). The T17-T18 space was not calculated due to the lack of collected data.

The average distance per intervertebral space between the two moments and between the two evaluators for the Arab foals is shown in Table 4.

TABLE 4. Interspinous spaces for Arab horses (ISS Arab) and the averages of each interspinous space for evaluators 1 and 2 between the two moments EV1M1, EV1M2, EV2M1 and EV2M2, average per evaluator (Average EV1 and Average EV2) and the Overall Average.

ISS Arab	EV1M1	EV1M2	Average EV1	EV2M1	EV2M2	Average EV2	Overall Average
T2-T3	14,5	15,3	14,9	14,2	14,3	14,3	**14,6**
T3-T4	11,6	12,0	11,8	11,1	11,6	11,4	**11,6**
T4-T5	13,1	13,7	13,4	12,9	13,2	13,1	**13,2**
T5-T6	15,1	16,7	15,9	15,1	16,3	15,7	**15,8**
T6-T7	15,8	18,1	17,0	16,0	17,4	16,7	**16,8**
T7-T8	14,4	16,1	15,3	14,0	15,6	14,8	**15,0**
T8-T9	12,8	13,7	13,3	12,2	13,2	12,7	**13,0**
T9-T10	11,0	11,5	11,3	10,5	10,8	10,7	**11,0**
T10-T11	8,6	8,7	8,7	8,5	8,3	8,4	**8,5**
T11-T12	8,2	8,0	8,1	8,7	7,9	8,3	**8,2**
T12-T13	7,7	7,4	7,6	7,9	7,0	7,5	**7,5**
T13-T14	6,0	5,7	5,9	6,0	5,5	5,8	**5,8**
T14-T15	5,0	4,9	5,0	5,1	4,6	4,9	**4,9**
T15-T16	5,2	5,3	5,3	5,0	4,7	4,9	**5,1**
T16-T17	5,4	5,5	5,5	5,0	5,3	5,2	**5,3**
T17-T18	5,8	5,9	5,9	5,6	5,6	5,6	**5,7**

For the Arab horses the lowest mean interspinous distance was found in the T14-T15 space, with 4.9 mm for all horses, at both times, and by both evaluators, which is the space just cranial to the anticlinal vertebra T15.

The lowest mean interspinous space distances at both moments for evaluators were found in the TB horses in the spaces between T13 and T18 (T13-T14 = 3.1 mm; T14-T15 = 2.5 mm; T15-T16 = 2.6 mm; T16-T17 = 2.8 mm and T17-T18 = 3.8 mm), with the shortest distance between T14-T15 (2.5 mm).

The average distance per interspinous spaces between the two moments and between the two evaluators for the TB foals is shown in Table 4.
For the TB animals in this study, the shortest average distance between spinous

processes were found in the T14-T15 space, with an average distance of 2.5 mm between all horses at both times and by both evaluators, which coincided with the space cranial to the anticlinal vertebra, T15, which anatomically coincided with the same space as the Arab horses, but with an average distance 2.4 mm smaller (51% shorter).

In addition, the distances between T13 and T18 were less than 4 mm on average, below the minimum anatomical radiographic limit.

TABLE 5: Intervertebral space for TB horses (IVS TB) and the averages of each interspinous space distance for evaluator 1 and 2 between the two moments EV1M1, EV1M2, EV2M1 and EV2M2, the average per evaluator (Average EV1 and Average EV2) and the Overall Average.

IVS TB	EV1M1	EV1M2	Average EV1	EV2M1	EV2M2	Average EV2	Overall Average
T2-T3	10,4	9,7	10,1	11,1	9,1	10,1	**10,1**
T3-T4	8,7	8,2	8,4	8,9	8,2	8,6	**8,5**
T4-T5	10,6	9,8	10,2	10,7	10,1	10,4	**10,3**
T5-T6	13,6	12,3	13,0	14,3	13,6	13,9	**13,5**
T6-T7	15,5	15,1	15,3	16,5	16,4	16,5	**15,9**
T7-T8	14,5	13,0	13,8	14,9	14,8	14,9	**14,3**
T8-T9	11,8	10,6	11,2	12,1	11,9	12,0	**11,6**
T9-T10	10,6	9,8	10,2	10,3	10,3	10,3	**10,2**
T10-T11	8,0	7,8	7,9	7,9	8,2	8,0	**8,0**
T11-T12	6,5	6,5	6,5	6,2	6,3	6,3	**6,4**
T12-T13	5,4	5,3	5,4	5,3	5,3	5,3	**5,3**
T13-T14	3,5	3,1	3,3	3,0	3,0	3,0	**3,1**
T14-T15	2,8	2,6	2,7	2,2	2,3	2,3	**2,5**
T15-T16	2,9	2,5	2,7	2,6	2,3	2,4	**2,6**
T16-T17	3,0	2,6	2,8	3,0	2,6	2,8	**2,8**
T17-T18	4,3	3,5	3,9	4,0	3,4	3,7	**3,8**

The Mann-Whitney test ($P<0.05$) was used for the radiographic findings with the proposed grading methodology of 0 to 4 (Table 1), where the two groups, Arab and TB breeds, were tested per evaluator and at both times.

Most of the animals with radiographic findings compatible with KSS had spaces between the spinous processes from T11 to T18 scored.

For radiographic findings graded 0 to 4, there was a statistically significant difference between the groups for both evaluators 1 and 2 (EV1 and EV2) at both times 1 and 2 (M1 and M2), between the spaces of T13-T14; T14-T15; T15-T16 and T16-T17 and, in the second evaluation (M2), between the spaces of T8-T9; T9-T10; T13-T14; T14-T15; T15-T16; T16-17 and T17-T18.

For the group of Arab horses, a small number of animals were classified as grade 1 by both evaluators. In the second assessment, all the animals in the Arab group were classified as grade 0. Table 6 below shows the findings of the Arab horses in the first assessment:

TABLE 6: Classification of radiographic findings compatible with KSS in the group of Arab horses for both evaluators. The values in the table refer to the intervertebral space (IVE Arab), evaluator 1 (EV1) and evaluator 2 (EV2) and grades from 1 to 4, at the first moment 1.

	M1 CLASSIFICATION - GRADE							
IVS Arab	**1**		**2**		**3**		**4**	
	EV1	EV2	EV1	EV2	EV1	EV2	EV1	EV2
T13-T14	1	0	0	0	0	0	0	0
T15-T16	2	1	0	0	0	0	0	0
T16-T17	1	0	0	0	0	0	0	0
T17-T18	4	3	0	0	0	0	0	0
Total	8	4	0	0	0	0	0	0

For the TB group, there was a wider and more significant occurrence of radiographic findings compatible with KSS, as shown in Table 7.

TABLE 7: Classification of radiographic findings compatible with KSS in the TB group for both evaluators, at the first moment (M1). The intervertebral space (IVS TB), evaluator 1 (EV1) and evaluator 2 (EV2) and grades 1 to 4, at the first moment 1.

	M1 CLASSIFICATION - GRADE							
IVS TB	**1**		**2**		**3**		**4**	
	EV1	EV2	EV1	EV2	EV1	EV2	EV1	EV2
T4-T5	1	1	0	0	0	0	0	0
T11-T12	7	6	0	0	0	0	0	0
T12-T13	12	11	1	1	0	0	0	0
T13-T14	21	18	6	5	0	2	1	1
T14-T15	30	28	4	5	4	4	0	0
T15-T16	26	20	3	5	6	4	1	1
T16-T17	15	13	5	8	2	1	4	4
T17-T18	18	15	1	3	2	2	0	0
Total	130	112	20	27	14	13	6	6

TABLE 8: Classification of radiographic findings compatible with KSS in the group of TB horses for both evaluators at the second moment (M2). The intervertebral space (IVS TB), evaluator 1 (EV1) and evaluator 2 (EV2) and grades 1 to 4, at second moment 2.

	M2 CLASSIFICATION - GRADE							
IVS TB	**1**		**2**		**3**		**4**	
	EV1	EV2	EV1	EV2	EV1	EV2	EV1	EV2
T2-T3	0	0	0	0	1	1	0	0
T3-T4	0	0	1	1	0	0	0	0
T4-T5	3	2	0	0	0	0	0	0
T5-T6	1	1	0	0	0	0	0	0
T6-T7	2	2	0	0	0	0	0	0
T7-T8	1	1	0	0	0	0	0	0
T10-T11	1	1	0	0	0	0	0	0
T11-T12	7	7	1	1	2	0	0	0
T12-T13	7	6	2	3	5	5	0	0
T13-T14	15	15	9	10	8	8	1	1
T14-T15	21	20	13	13	8	8	1	1
T15-T16	15	15	12	12	9	9	1	1
T16-T17	16	16	9	11	7	6	2	1
T17-T18	9	9	11	11	1	2	0	0
Total	98	95	58	51	41	39	5	4

DISCUSSION

The PSI breed was selected for this study because it is a fast breed that is used worldwide for turf racing but is also suitable for other types of equestrian events such as show jumping, as well as straight track racing. They are present at various equestrian events throughout the country.

On the turf, they begin their first work in training, trotting, cantering and galloping, which prepares them for their first competitions when they are two years old, the age when they reach full bone and body maturity, for both males and females.

The main turf racetracks are in the cities of Curitiba, Porto Alegre, Rio de Janeiro and São Paulo. In the State of São Paulo, there is the main center, the Hipódromo Paulistano, which is the Jockey Club of São Paulo, in the capital city of São Paulo and a training center in Campinas, which makes this activity important for job creation, for leisure, which arouses interest in the national equine culture and for veterinarians involved in all stages of this activity.

The Thoroughbred (TB) is a prevalent horse breed for the occurrence of Kissing Spine Syndrome (KSS), already searched by retrospective and prospective studies, who’s some of them, more recently published, were chosen as bibliographic references for this study.

The Arabian (Arab) horse in Brazil is designated to perform in equestrian endurance events, which challenge the animal's resistance, constancy, physical and mental capacity, as well as halter, racing, jumping and rural equestrian events, widespread throughout the country and in international competitions of endurance.

The interest in choosing the two breeds is because the Arab is the breed that forms the TB breed. This study was interested in researching whether today's purebred Arab horses in Brazil have scientific evidence of being prevalent in the early onset of KSS.

Arab horses are tamed later than others, which requires a longer period for restraint on radiographic examinations. However, a correlation can be made for the radiographic findings of KSS and for the distance of the interspinous spaces from T2 to T18, for an interracial comparative study with TB.

The age of two years-old was chosen because at this age TB horses are tamed and training begins, which contributed to the management of these animals when carrying out radiographic examinations.

The presence of TB foals in the Training Centers helps to the logistics of acquire the images and to the choice of horses used.

Another factor in choosing the age of the individual’s cohort for the sampling of this study is because they are beginners, reducing the possibility of injuries caused by repetitive and intense exercise.

The TB horses normally remain in training at the racetrack until the age of five or even longer, which increases the likelihood of losing the animals in this work during the interval between the first and second moments.

Animal restraint and positioning is essential for the radiographic findings. The emission of the central beam at an oblique angle can promote a deceptive overlap of the spinous processes and compromise the statistical analysis of this group of selected animals.

Magnification and distortion of images can lead to inadequate measurement, with greater error, when measuring interspinous spaces.

The minimal distortion of the images obtained in this study may have resulted in inaccurate measurement, despite care taken regarding good positioning of the animal and focus on emission of the anatomical areas of interest.

The power of the X-ray generator is a subject with different opinions in the discussion of articles taken as references. A small group of authors validates the use of low-performance portable equipment, citing that the equipment must be fixed, as it has greater power and is supported on a support to allow stability of the machine (16).

The use of the portable machine in this work, with the exposure factors already mentioned in Materials and Methods item, proved to be extremely efficient for the cranial and middle portions of the spine of the thoracic segment of TB horses, which weighed between 420 and 540 kg, with slight to moderate loss of penetration and image resolution only in the caudal portion, notably from T14-T15 to T18.

Performing the images without sedation of TB group was an important factor, since according to literature, sedation causes muscle relaxation in the back, which can increase the distance between the spinous processes of thoracic vertebrae and alter compatible findings with KSS.

The number of three sequential images, focusing on a specific anatomical point, was determined during some tests carried out before this work began. Therefore, it was planned to center the spinous processes in each image directed at T2, T6 and T12, which demonstrated to be a protocol applied in research.

The pre-determined focal points were of great importance, as they helped the repetition of references between animals, either the TB and the Arab breed, and proved to be an excellent external reference on the body of each animal, as a positioning standard. The accuracy and speed in capturing well-positioned images will help repetition this criterion in future studies.

Taking three images is quick to study each animal, without the need to sedate the majority, ensuring lower imaging costs and causing less discomfort and stress to the animals, with the aim of maintaining the well-being of the horses used, who returned to their routine without any demonstration of irritation or aggressive behaviour, factors to alter the training progress of the TB horses.

The position of the head depended on the collaborates with good image acquisition, because the neck is connected by the nuchal ligament to the dorsal spinous processes T1-T5. A higher neck determines greater dorsal flexion of the spine, while a lower neck determines greater dorsal extension of the spine. The ideal head position is closer to natural, because this way the values obtained in measurements comply with greater precision in distances.

The T1 vertebra was not taken into consideration and the radiographic images did not capture the T1 spinous process, as it is shorter and more distant from T2 and due to the lack of reports in the literature involving T1 on KSS.

The size of the plate was adequate in the dimensions of 35 x 43 cm, as the anatomical structures of interest are well framed, and a panoramic image contributes to the detection of radiographic changes in the KSS and measurements between the spinous processes.

The results obtained corroborates the work of other authors regarding the greater occurrence of KSS in TB. At two years, it was demonstrated that a significant number of horses tested had radiographic findings typical to KSS.

The spaces that presented the highest degree in the findings, T14-T15 and T15-T16, confirmed the expectations about the spaces that would present a greater occurrence of radiographic changes, as they involve the anticlinal T15 vertebra, where the conformation changes in relation to the other spaces (12).

This result which demonstrates that the smallest interspinous spaces are in intervertebral joints that involve the anticlinal T15 vertebra, may be evidence that there is an anatomical factor intrinsic to vertebral biomechanics in this vertebral segment, which may increase the risk of KSS in this region.

The limit interspinous distance to determine whether there is narrowing or not is 4 mm, cited by several authors (24; 23), which demonstrated that TB horses have a reduction in the interspinous space between T13 to T18 at two years of age and that there was no significant statistical variation between the moments. This result may be an anatomical-radiographic characteristic intrinsic to the TB breed. Arab horses, in addition, shown not to have spaces shorter than 4 mm, as well as an increase in the distance between spaces T5-T6 (15.1 ± 2.6 at moment 1 and 16.7 ± 2.2 at moment 2); T6-T7 (15.9 ± 2.7 at moment 1 and 18.1 ± 2.3 at moment 2) and T7-T8 (14.4 ± 2.7 at moment 1 and 16.1 ± 2.0 at time moment 2), which coincides with the vertebrae that have a secondary ossification nucleus in ongoing growth that lasts around 15 years between T2 and T6 (12).

To be better interpreted those results, it suggests that deeper studies ought to be carried out on vertebral development in horses till bone growth ceased and in the first years of bone maturity, to understand the anatomical relationship between the bone growth of the spinous processes and the distance from the interspinous processes.

CONCLUSIONS

The focal points determined at T2, T6 and T12 are a method that can be applied to evaluate the thoracic segment of the spinous processes for radiographic findings and to classify the degree of KSS, because they help better centring of the images for spine radiography. The measurements obtained in the spaces between T2 and T18 at an interval of six months demonstrated that there are significant differences in the spaces determined. TB horses have a higher occurrence of radiographic signs of KSS compared to Arab horses. The interspinous distances between T2 and T18 can be used as a reference for the average distance for each breed.

REFERENCES

1. ALVES, A. L. G.; FONSECA B. P. A.; THOMASSIAN A.; NICOLETTI. J. L. M.; HUSSNI, C. A.; SILVEIRA, A. B. Brazilian Journal of Veterinary Research in Animal Science, São Paulo, v. 44, n. 3, p. 191-199, 2007.

2. BERNER D.; WINTER K.; BREHM W.; GERLACH K. Influence of head and neck position on radiographic measurement of intervertebral distances between thoracic dorsal spinous processes in clinically sound horses. Equine Veterinary Journal, v. 44, p. 21-26, 2012.

3. BUTLER, J. A.; COLLES, C.; DYSON, S.; KOLD, S.; POULOS, P. Clinical Radiology of the Horse, Fourth Edition, Blackwell Publishing Company, 2016.

4. CLAYTON, H. M.; STUBBSB N. C. Enthesophytosis and Impingement of the Dorsal Spinous Processes in the Equine Thoracolumbar Spine. Journal of Equine Veterinary Science, v. 47, p. 9-15, 2016.

5. DJERNÆS J. D.; NIELSEN J. V.; BERG L. C. Effects of X-ray beam angle and geometric distortion on width of equine thoracolumbar interspinous space using radiography and computed tomography — a cadaveric study. Veterinary Radiology and Ultrasound, v. 00, n. 0, p. 1-7, 2016.

6. DOMANSKA-KRUPPA, N.; WIERZBICKA, M.; STEFANIK, E. Advances in Clinical Diagnostics to Equine Back Pain: A Review of Imaging and Functional Modalities. Animals, v. 14, 698, p. 1-16, 2024.

7. ERICHSEN, C.; EKSELL, P.; HOLM, K. R.; LORD, P.; JOHNSTON, C. Relationship between scintigraphic and radiographic evaluations of spinous processes in the thoracolumbar spine in riding horses without clinical signs of back problems. Equine Veterinary Journal, v. 36, p. 458-465, 2004.

8. FONSECA B. P. A.; ALVES, A. L. G.; HUSSNI, C. A. Clinical exam protocol for the equine thoracolumbar spine. Brazilian Journal of Veterinary Research in Animal Science, São Paulo, v. 48, n. 4, p. 271-280, 2011.

9. INFANTEA D.; CROXATTOB A.; CORREA F. Radiologic findings consistent with kissing spines syndrome in Chilean thoroughbreds’ horses. Sustainability Agri, Food and Environmental, Researchgate, v. 4, p. 14-17, 2017.

10. JANECZEK, M.; CHRÓSZCZ, A.; ONAR, A.; HENKLEWSKI, R.; PIEKALSKI, P.; DUMA, P.; CZERSKI, A.; CAŁKOSIŃSKI, I. Anatomical and Biomechanical Aspects of the Horse Spine: The Interpretation of Vertebral Fusion in a Medieval Horse from Wroclaw (Poland). International Journal of Osteoarchaeology, John Wiley & Sons, Ltd., 2012.

11. JEFFCOT, L. B. Radiographic Features of the Normal Equine Thoracolumbar Spine. American College of Veterinary Radiology, v. 20, p. 140- 147, 1979.

12. JOHNS, S.; ALLEN, A. K.; TYRRELL, L. A. How to Obtain Digital Radiographs of the Thoracolumbar Spine in the Standing Horse. AAEP Proceedings Vol. 54, p. 455-458, 2008.

13. KÖNIG, H. E.; LIEBICH, H.-G. Anatomia dos animais domésticos: texto e atlas colorido, 6ª ed. Artmed, Porto Alegre, 2016.

14. MANSO-DÍAZ, G.; ROMÁN, J., L. S.; WELLER, R. A Practical Guide to Equine Radiography, 5M Publishing, 2018.

15. PIGÉ, C.; MASSEAU, I.; BONILHA, A. G. Influence of abdominal elevation on radiographic measurements of the thoracolumbar interspinous spaces in asymptomatic horses. Canadian Veterinary Journal, v. 61, p. 1101-1105, 2020.

16. PRESSANTO M. C.; PEPE M.; COOMER R. P. C.; PILATI N.; BECCATI F. Radiographic abnormalities of the thoracolumbar spinous processes do not differ between yearling and trained Thoroughbred horses without perceived back pain. Journal of American Veterinary Medicine Association, v. 261, n. 6, p. 844-851, 2023.

17. ROSA L. P.; WHITAKER B.; ALLEN K.; PETERS D.; BUCHANAN B.; McCLURE S.; HONNASF C.; BUCHNAN C.; MARTIN K.; LUNDQUIST E.; VIERRA M.; FOSTER G.; BROOKS S. A.; LAFAYETTE C. Genomic loci associated with performance limiting equine overriding spinous processes (kissing spines). Research in Veterinary Science, v. 150, p. 65-71, 2022.

18. ROSS, M. W.; DYSON, S. J. Diagnosis and Management of Lameness in the Horse 2nd Edition, Elsevier Saunders, 2010.

19. SCHULTZ, R. M.; ELBRØND, V. S. Novel dissection approach of equine back muscles: new advances in anatomy and topography - and comparison to present literature. Science Publishing Group Journal, p. 1-13, 2018.

20. SINDING M. F.; BERG L. G. Distances between thoracic spinous processes in Warmblood foals: A radiographic study. Equine Veterinary Journal, v. 42, n. 6, p. 500-503, 2010.

21. ZIMMERMAN M.; DYSON S.; MURRAY R. Close, impinging and overriding spinous processes in the thoracolumbar spine: The relationship between radiological and scintigraphic findings and clinical signs. Equine Veterinary Journal, v. 44, p. 178-184, 2011.

22. ZIMMERMAN M.; DYSON S.; MURRAY R. Comparison of Radiographic and Scintigraphic Findings of the Spinous Processes in the Equine Thoracolumbar Region. Veterinary Radiology and Ultrassound, v. 52, n. 6, p. 661-671

CAPÍTULO 3

Trabalho a ser enviado para Orthopaedic Surgery
Journal Online ISSN:1757-7861, ISSN:1757-7853
Title: Occurrence of Impingement of Spinous Processes of Thoracic Vertebrae (Kissing Spines) in 2-Year-Old Arabian horses.

Keywords: Radiology; Back pain; Vertebrae
Running head: Gallo et al. Kissing Spines in 2-Year-Old Arabian Horses.

Marco Aurélio Gallo [1 ID], Alessandra Regina Dhom Pimentel de Moraes [1],
Vania Maria de Vasconcelos Machado [1]
1 Department of Animal Reproduction and Veterinary Radiology
São Paulo State University (Unesp), Botucatu, SP, Brazil

Correspondence
Vania Maria de Vasconcelos Machado, Faculdade de Medicina Veterinária e Zootecnia - Câmpus de Botucatu
Rua Prof. Doutor Walter Mauricio Correa, s/n - Unesp Campus de Botucatu
- Botucatu/SP - CEP 18618-681
E-mail: vania.mv.machado@unesp.br

Funding information
São Paulo State University (Unesp), Botucatu, SP, Brazil

Conflict of interest statement.
The authors declare that there are no conflicts of interest

ABSTRACT

The spine is essential for equestrian activities and high performance. Back pain originating in the spine can compromise activities intended for horses, such as competition and breeding. The thoracolumbar segment is present in the region where the rider's saddle rests and can generate pain, which is a problem that should be avoided, quickly detected and the prognosis and treatment promptly established. The impingement or overriding of the spinous processes of the vertebrae in the thoracolumbar region, classically called Kissing Spines Syndrome (KSS), is a condition that affects horses, responsible for the decrease in efficiency in their activities and considered the main cause of back pain. There are studies that seek to better understand its occurrence, considering the age, sex, breed and sport activity in which the horse participates, which may be factors that increase the risk of KSS; however, the determining cause is not yet fully elucidated, although it is known that genetic and environmental factors are involved. Imaging methods seek to track anatomical changes compatible with KSS. Nonetheless, the correlation between imaging findings and clinical manifestations needs to be improved through more in-depth studies in symptomatic and asymptomatic horses to establish more assertive diagnostic criteria. Radiological examination is a fast, efficient and inexpensive imaging method, accessible to equine clinicians working in research and field practitioners, which makes it a very useful tool for better understanding the characteristics of KSS. This article aims to establish a practical radiographic positioning criterion to aid the diagnosis of KSS and screen its occurrence in young Arabian horses at two years of age and before training begins. Twenty-six of two-year-old Arabian horses were x-rayed using portable equipment where three images were obtained in laterolateral projection with focal points on the skin over the spinous processes of T2, T6 and T12 to ensure the centralization of focal points. The images obtained were carefully evaluated by two examiners who measured the spaces between the spinous processes from T2 to T18 and observed the presence of radiographic evidence of Kissing Spines at two moments with an interval of five months. The collected data were inserted into tables where the average measurements of each space at both moments were obtained and the findings compatible with Kissing Spines were classified on a numerical scale. The smallest distance obtained

was 4.9 mm in the space between T14 and T15. Significant statistical differences occurred in five-month intervals on T5-T6, T6-T7 and T7-T8 by both observers and unexpectedly they were all wider in average. The statistical radiological findings compatible to kissing spines detected by the observers among the group were irrelevant. These results could be evidence that the imaging diagnosis of kissing spines should considered at a minimal age to be still established, concerning the physiological vertebral body growth.

Key words: radiology, back pain, vertebra, performance, foals.

INTRODUCTION

Pain in the back of horses is a common reason for complaints from the owner or trainer, especially with poor athletic performance (1; 2). Diagnosing the cause of back pain in horses becomes a hard task to perform on a routine basis due to the great thickness of the anatomical region, where imaging approach becomes a challenging procedure (3; 1).

Detailed information on the anatomical aspects of the spine radiographies in horses was published in the 1970s (4) and complemented details with digital imaging (5; 6).

Back pain worries the staff of equestrian activities, as it causes limitations to performance, concerns about health examinations in equestrian competitions or racing events, in pre-purchase radiographs and finally by causing discomfort and impacting the welfare of horses (3; 7; 8; 1; 9).

Overriding the spinous processes of vertebrae or Kissing Spine Syndrome (KSS) is a condition that arouses the interest of equine sports veterinarians regarding the exact anatomical site of the location of pain, due to limiting performance and well-being, as it affects general health and finally, in detecting risk factors in asymptomatic animals that may develop, during training, clinical signs and symptoms of KSS (1; 9).

In the spinous processes in the thoracolumbar spine in sports horses, anatomical changes can be found on radiography or scintigraphy (1). Morphological changes or positioning of the spinous processes induce pain and are responsible for economic losses in treatment and disposal of horses from their role (9). The overlapping or crowding of the spinous processes, in addition to fractures or possible malformations, are imaging findings observed on studies of adults and young horses, even before they complete their entire growth (4; 10).

Correlation between the findings in imaging exams and clinical manifestations as a specific cause of back pain or failure during athletic activity becomes a challenging task, even for a professional experienced in clinical diagnosis and image evaluation (11).

The mismatch between radiographic findings and clinical signs of KSS makes its diagnosis even more intriguing (10).

The equine industry has selected horses for sporting performance and leisure, which may suffer lameness of unknown origin during their activity, and which is caused by back pain due to the demand of protective entities, permeated by criticism from social media regarding promoting animal well-being (12).

METHODS

The objective in carrying out this study lies in the importance of screening a group of asymptomatic young horses to understand the occurrence and early onset of this syndrome and establish radiographic positioning criteria and measures that can contribute to its diagnosis in the population of young Arabian horses, before taming and compare the results in six-month interval, with the help of portable digital radiography equipment.

Another data was assembled to determine the average distance of interspinous processes distances on sedated Arabian horses in time when they reach the entire body development and before ridding for competition seasons.

The study included 26 untamed horses of the Pure Arabian bred, 13 females (50%) and 13 intact males (50%), which will compete in equestrian endurance events in the future. On the date of the first moment, all horses used had completed two years of age and had not yet completed three years of age.

At the first moment, the images were acquired in September of 2023 and the second moment in February of 2024, in an interval of five months.

All the animals were subjected to sedation with 1% detomidine hydrochloride, intravenously into the jugular vein, at a dose of 20 to 40 µg/kg.

Approximately three minutes after administration of the sedative, the animals allowed the radiographic examination to be carried out.

None of the horses had any external sign of spinal injury in any segment or clinical history of the presence of spinal injuries, lameness, back pain, motor incoordination or having been subjected to any local or systemic treatment.

The distance in millimeters was measured between the caudal surface of a spinous process of a cranial vertebra and the cranial surface of its subsequent caudal anatomical structure, from T2 to T18, sixteen interspinous processes spaces measured per horse.

The height of the ideal point to measure the distance was considered the smallest distance between the intervertebral spaces, after training the evaluators. The equipment used consisted of a portable panel (DR), with Cesium Iodide scintillator, measuring 35 X 43 cm (CareRay Digital Medical Technology Co., Ltd., Suzhou, China) and a portable X-Ray generator (JOB Corporation, Yokohama, Japan).

The pre-determined focal points were on the spinous processes of T2, T6 and T12, three images per horse on laterolateral projection, with the panel placed on the right side of the thoracic spine.

The T2-focused image was obtained with the lead adhered to the muscular belly of the subclavian muscle, cranially to the proximal end of the scapular spine, for the evaluation and study of the T2 to T6 segment. The image in the highest portion of the withers, which corresponded to the spinous process of T6, to evaluate the segment between T6 and T12 and the image focusing on T12, to evaluate the segment between T12 and T18, was obtained with a palpable point at the beginning of the portion flatter back.

The immobility of horses during acquisition of images was considered. At the time of the horse positioning, the stability of the animal was observed, as well as the reduction in contraction movements of the back and subcutaneous muscles in the anatomical areas of interest, to avoid distorted and magnified images, which could confuse the evaluator when counting the vertebrae.

Care was taken to the head maintained in a neutral position and height, with the nasal suture aligned with the withers and the lip corner at the shoulders.

The horses used for the study were healthy animals, resident in the state of Sao Paulo, in stud farms of the Arabian breed, where there is great concern in maintaining the well-being of the horses housed.

The One-Way Repeated Measure test ($P<0.05$) was performed to compare the measurements of the interspinous spaces at the first moment (M1) and second (M2) for both evaluators individually.

RESULTS

There was a statistically significant difference between moments 1 and 2 ($P<0.050$) for the spaces between T5-T6 ($P = 0.018$), T6-T7 ($P = 0.001$) and T7-T8 ($P = 0.002$) in the tested group for evaluator 1 (EV1) and there was a statistically significant difference between the spaces T2-T4 ($P=0.042$), T5-T6 ($P=0.004$), T6-T7 (0.006) and T7-T8 (0.003) for evaluator 2 (EV2). In the other spaces there were no differences.

The lowest average distance between the spinous processes was found in the T14-T15 space, 4.9 mm between all horses, at both moments and evaluators, including the anticlinal vertebrae T15.

The average interspinous space distance (ISD) in the separate two moments for the evaluator 1 (EV1M1 and EV1M2) and for the evaluator 2 (EV2M1 and EV2M2), the average per evaluator 1 (AVGEV1) and 2 (AVGEV2) and the average between the evaluators 1 and 2 (AVGEV1&2) is shown in Table 1.

DISCUSSION

The vertebral growth related to age on Arabian horses is probably different compared do other larger breeds, like Thoroughbreds and Warmbloods horses.

Significant statistical differences occurred in five-month intervals on T5-T6, T6-T7 and T7-T8 by both observers and, unexpectedly, they were all wider in average. These results may be related to ongoing developmental vertebral endochondral growth on the tips of T2 to T7 (4; 5).

On the other hand, there was no interspinous space measure thinner than 4 mm, on which the literature published stated being a threshold minimal space to consider narrowing, that suggests KSS based on radiographic features.

For the Arabian horses the lowest average in interspinous spaces was found in the T14-T15, with an average distance of 4.9 mm at both moments and evaluators, which matches the space cranial to the vertebrae T15. This lowest distance may be due to normal anatomical characteristics of intervertebral spaces on horses, when compared to another mammals, like dogs, in which the first cranial intervertebral space related to the anticlinal vertebra is normally thinner.

CONCLUSIONS

The numeric score for interspinous distances based on radiographic features in the hole spine ought to be adjusted in the determined breed to more accurately evaluate the occurrence of KSS. The ongoing bone growth of the thoracic vertebrae from T2 to T7 and the role that the anticlinal T15 vertebrae play on the distance of the interspinous space should be deeper investigated in future research to trace more accurate method of classifying the KSS.

ACKNOWLEDGMENTS

We would like to thank all the authors, especially the corresponding author of this study, as this study was conducted under his guidance.

REFERENCES

1. Zimmerman M, Dyson S, Murray R. Pain in the back of horses and its impact on performance. Equine Vet J. 2011;43 (1):1-8.

2. Rosa LP, Whitaker B, Allen K, Peters D, Buchanan B, McClure S, et al. Welfare concerns in horses: the impact of back pain on performance. J Equine Vet Sci. 2022;93:102923.

3. Erichsen C, Eksell P, Roethlisberger Holm K, Lord P, Johnston C. Diagnosing back pain in horses: Challenges and imaging techniques. Vet J. 2004;168(3):312-318.

4. Jeffcot LB. Radiographic anatomy of the equine spine. Equine Vet J. 1979;11(2):59-65.

5. Butler JA, Colles C, Dyson S, Kold S, Poulos P. Advances in digital imaging of the equine spine. Equine Vet Educ. 2016;28(6):309-317.

6. Manso-Díaz G, Román JL, Weller R. Morphological changes in equine vertebrae and their effects on athletic performance. Equine Vet J. 2018;50(7):951-957.

7. Alves ALG, Fonseca BPA, Thomassian A, Nicoletti JLM, Hussni CA, Silveira A. The impact of back pain in equestrian athletes. J Equine Vet Sci. 2007;27(10):469-475.

8. Fonseca BPA, Alves ALG, Hussni CA. Diagnosis and treatment of back pain in horses. Vet J. 2011;187(1):55-62.

9. Pressanto MC, Pepe M, Coomer RPC, Pilati N, Beccati F. Kissing spine syndrome in sport horses: A review of clinical and imaging findings. Equine Vet J. 2023;55(6):741-749.

10. Sinding MF, Berg LG. Overlapping spinous processes in the thoracolumbar spine of horses: radiographic findings and clinical implications. Acta Vet Scand. 2010;52(1):16

11. Infantea D, Croxatto A, Correa F. Clinical manifestations of Kissing Spine Syndrome in horses and its radiographic evaluation. Equine Vet Educ. 2017;29(8):454-460.

12. Domanska-Kruppa N, Wierzbicka M, Stefanik R. Back pain in horses used in competitive and leisure activities. J Equine Vet Sci. 2024;105:102746.

Table 1. Average interspinous space distance

IVS	EV1M1	EV1M2	AVGEV1	EV2M1	EV2M2	AVGV2	AVGEV1&2
T2-T3	14,5	15,3	14,9	14,2	14,3	14,3	**14,6**
T3-T4	11,6	12,0	11,8	11,1	11,6	11,4	**11,6**
T4-T5	13,1	13,7	13,4	12,9	13,2	13,1	**13,2**
T5-T6	15,1	16,7	15,9	15,1	16,3	15,7	**15,8**
T6-T7	15,8	18,1	17,0	16,0	17,4	16,7	**16,8**
T7-T8	14,4	16,1	15,3	14,0	15,6	14,8	**15,0**
T8-T9	12,8	13,7	13,3	12,2	13,2	12,7	**13,0**
T9-T10	11,0	11,5	11,3	10,5	10,8	10,7	**11,0**
T10-T11	8,6	8,7	8,7	8,5	8,3	8,4	**8,5**
T11-T12	8,2	8,0	8,1	8,7	7,9	8,3	**8,2**
T12-T13	7,7	7,4	7,6	7,9	7,0	7,5	**7,5**
T13-T14	6,0	5,7	5,9	6,0	5,5	5,8	**5,8**
T14-T15	5,0	4,9	5,0	5,1	4,6	4,9	**4,9**
T15-T16	5,2	5,3	5,3	5,0	4,7	4,9	**5,1**
T16-T17	5,4	5,5	5,5	5,0	5,3	5,2	**5,3**
T17-T18	5,8	5,9	5,9	5,6	5,6	5,6	**5,7**

Intervertebral Space IVS. Average interspinous space distance in the separate two moments for the evaluator 1 (EV1M1 and EV1M2) and for the evaluator 2 (EV2M1 and EV2M2), the average per evaluator 1 (EVGEV1) and 2 (EVGEV2) and the average between the evaluators 1 and 2 (EVGEV1&2).

FIGURE LEGENDS

FIGURE 1. Arabian 2-y-o mare just after sedation with the focal point of T2 determined by lead fishing pallet adhered with micropore tape (arrow). The focal point of T6 on the withers being palpated. The head was aligned with the spine in neutral height.

FIGURE 2. Focal point for T2 where the lead fishing pallet is adhered with micropore tape over de subclavius muscle cranial to the cranial surface of the scapula.

FIGURE 3. Laterolateral digital radiography of an Arabian horse taken with de flat panel on the right side of the cranial withers. The markers appear clearly on the tip of T2 and T6. The interspinous spaces are measured in millimeters by the viewer.

FIGURE 4. Laterolateral digital radiography of an Arabian horse taken with de flat panel on the right side of the caudal withers. The markers appear clearly on the tip of T6 and T12. The interspinous spaces are measured in millimeters by the viewer.

FIGURE 5. Laterolateral digital radiography of an Arabian horse taken with de flat panel on the right side of the midback. The markers appear clearly on the tip of T12. The interspinous spaces are measured in millimeters by the viewer.

FIGURES

Figure 1

Figure 2

Figure 3

Figure 4

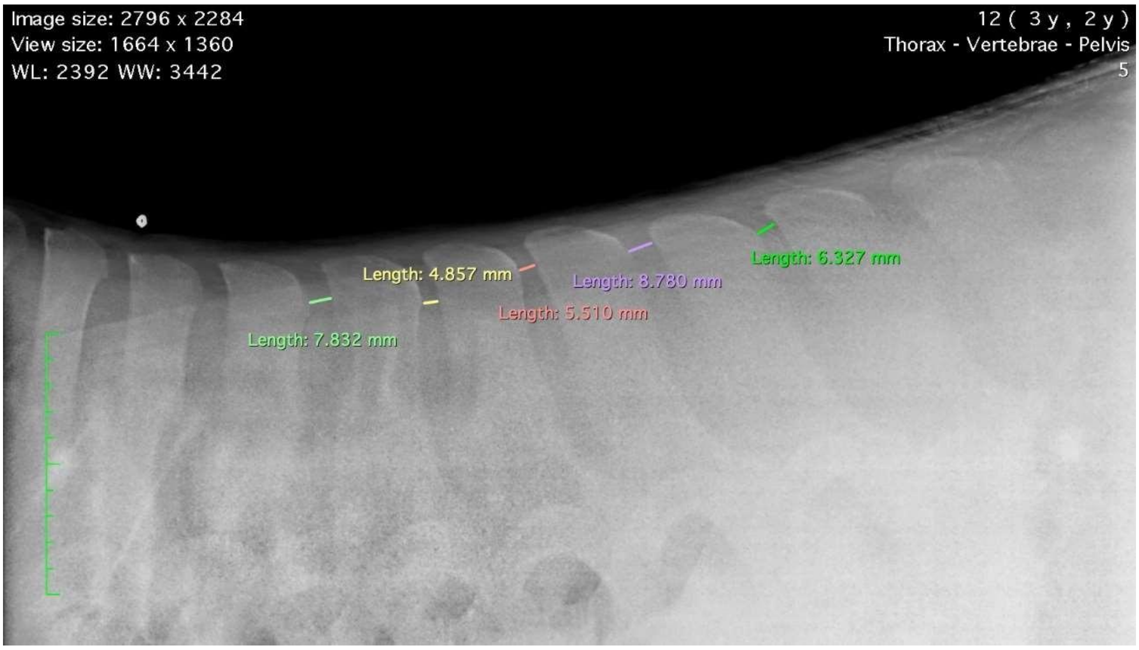

Figure 5

ANEXOS

Author Guidelines for Submitting to Veterinary Radiology and Ultrasound Journal.

Free Format submission

Veterinary Radiology & Ultrasound now offers Free Format submission for a simplified and streamlined submission process. Before you submit, you will need: Anonymized and deanonymized versions of your manuscript: the anonymized version should have all author identifiers removed for double-anonymized peer review; both versions should be editable files including text, figures, and tables, or separate files—whichever you prefer. All required sections should be contained in both versions of your manuscript, including abstract, introduction, methods, results, and conclusions. Figures and tables should have legends. Figures should be uploaded in the highest resolution possible. If the figures are not of sufficiently high quality your manuscript may be delayed. References may be submitted in any style or format, as long as it is consistent throughout the manuscript. Supporting information should be submitted in separate files. If the manuscript, figures or tables are difficult for you to read, they will also be difficult for the editors and reviewers, and the editorial office will send it back to you for revision. Your manuscript may also be sent back to you for revision if the quality of English language is poor.

An ORCID ID number for all co-authors, freely available at https://orcid.org. (Why is this important? Your article, if accepted and published, will be attached to your ORCID profile. Institutions and funders are increasingly requiring authors to have ORCID IDs.)

The title page of the manuscript (please see Title Page section below for details on what should be included).

An Animal Use and Financial Disclosure form: available for download from the "Resources; Instructions and Forms" link on the Manuscript Central Main Menu: http://mc.manuscriptcentral.com/vru.

Article Preparation Support

Wiley Editing Services offers expert help with English Language Editing, as well as translation, manuscript formatting, figure illustration, figure formatting, and graphical abstract design – so you can submit your manuscript with confidence. Also, check out our resources for Preparing Your Article for general guidance about writing and preparing your manuscript.

Open Access

Veterinary Radiology & Ultrasound is a subscription journal that offers an Open Access option. You'll have the option to make your article open access after acceptance, which will be subject to an APC unless a waiver applies. Read more about APCs here.

Title Page

The title page should contain:

Title: A brief informative title. The title should communicate the most important findings from the study (include the title in both blinded and unblinded versions). The title should not contain abbreviations (see Wiley's best practice SEO tips);

Authors: The full names of the authors. Include the first name (no initials), middle name or initial(s) (optional), last name of all authors.

Affiliations: The author's institutional affiliations where the work was conducted, with a footnote for the author's present address if different from where the work was conducted. Provide name and address of authors' departments and/or institutions (use superscript letters before different institutions to identify different author affiliations). Provide Corresponding Author name, address, email address; Key Words: please provide 3-5 key words that are not in the title or abstract and that would also help other researchers find your paper.

Conflict of Interest Disclosure: state whether any authors have a conflict of interest. See details in the relevant section below.

Previous Presentation or Publication Disclosure: describe any previous meeting presentations, abstracts, etc;

Reporting Checklist Disclosure: please indicate whether an EQUATOR network (http://www.equator-network.org/) or other reporting checklist was used (examples: CONSORT, STROBE, STROBE-VET, REFLECT, ARRIVE, PRISMA, STARD, CLAIM, CARE, GRRAS, PROCESS, REFLECT);

Abbreviations (optional): if non-standard abbreviations are used in the paper (i.e.)

abbreviations other than those commonly used for imaging modalities or measurement units), please define them here;

Data Accessibility Statement: please disclose how readers could access data supporting the results in this paper (examples: public data repository with link, other contact information).

Main Document File

Veterinary Radiology & Ultrasound operates a double-anonymized peer review process, please provide anonymized and deanonymized versions of the main document. Please ensure that all identifying information such as author names and affiliations, acknowledgements or explicit mentions of author institution are removed from the anonymized version of the main document. The main document file should be in Word format.

Your main document file should include:

Abstract

Text, Original Investigations (Learn more here.)

Text, Imaging Diagnosis (Learn more here.)

Text, Radiation Therapy Communication (Learn more here.)

List of Author Contributions

Acknowledgements

References.

Tables (each table complete with title and footnotes);

Figure legends (figures should be supplied as separate files);

Appendix

Abstract

The abstract should contain < 250 words (100 words for Imaging Diagnosis submissions) and should not be broken down into subheadings.

The abstract should state the importance of the problem being addressed, the study's purpose, study design (see Study Design Glossary), basic procedures (selection of study subjects, observational and analytical methods), most important findings (giving specific effect sizes and their statistical significance, if possible), and most important conclusions.

The abstract should emphasize new and important aspects of the study or observations.

List of Author Contributions

Veterinary Radiology & Ultrasound requires that all authors complete an authorship statement. All persons designated as authors should qualify for authorship. Each author should have participated sufficiently in the work to take public responsibility for the content. Authorship credit should be based only on substantial contributions to:

Category 1

(a) Conception and Design: Author name (s)

(b) Acquisition of Data: Author name (s)

(c) Analysis and Interpretation of Data: Author name (s)

Category 2

(a) Drafting the Article: Author name (s)

(b) Reviewing Article for Intellectual Content: Author name (s)

Category 3

(a) Final Approval of the Completed Article: Author name(s)

Category 4

(a) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: Author name (s)

Categories 1, 2, 3 and 4 must all be met. Participation solely in the acquisition of funding or the collection of data does not justify authorship. General supervision of the research group is not sufficient for authorship. Any part of an article critical to its main conclusions must be the responsibility of at least one author.

Editors may ask authors to describe what each contributed; this information may be published. Increasingly, multicenter trials are attributed to a corporate author. All members of the group who are named as authors, either in the authorship position below the title or in a footnote, should fully meet the above criteria for authorship. Group members who do not meet these criteria should be listed, with their permission, in the Acknowledgments or in an appendix. The order of authorship should be a joint decision of the coauthors. Because the order is assigned in different ways, its meaning cannot be inferred accurately unless it is stated by the authors. Authors may wish to explain the order of authorship in a footnote. In deciding on the order, authors should be aware that many journals limit the number of authors listed in the table of contents and that the U.S. National Library of Medicine (NLM) lists in MEDLINE only the first 24 plus the last author when there are more than 25 authors.

All listed authors need to be included as contributors to some part of each of the four categories in the Authors Contribution section of the unblinded manuscript. If not, they need to be listed in the acknowledgments, and not as an author.

Acknowledgments

List contributors to the paper who did not meet the criteria for authorship. Examples of those who might be acknowledged include clinicians/pathologists doing their usual duties; observers in multi-observer studies; a person who provided purely technical help, writing assistance, statistical analyses; or a department chairperson who provided only general support.

Financial and material support should also be acknowledged.

Acknowledge only persons who have made substantive contributions to the study.

Authors should obtain written permission from everyone acknowledged by name because readers may infer their endorsement of the data and conclusions. The journal accepts no responsibility for individuals acknowledged without their permission.

Reference Style

Veterinary Radiology & Ultrasound uses AMA reference style. As the journal offers Free Format submission, however, this is for information only and you do not need to format the references in your article. This will instead be taken care of by the typesetter.

Tables

Tables that concisely summarize results of descriptive and statistical analyses are encouraged. Tables describing individual patient details are discouraged. If authors strongly believe these details are critical for understanding the paper, the tables may be submitted separately as supplementary file(s).

Number all tables and supplementary files consecutively with Arabic numbers in order of appearance and insert a citation for each table and supplementary file at the most relevant location in the text section of the main document. Ex.

(Table 1, Supplement 1).

Insert page or section breaks between tables.

Provide a title for each table that concisely summarizes the information provided. Place units of measurement and numbers of subjects in the column headings.

Place explanatory information in footnotes, not in the heading. For multiple footnotes, use Latin lowercase letters in superscript.

Use asterisks (or symbols) for statistically significant values.

Figures and Figure Legends

Figures should be supplied as separate files.

Photoshop is preferred for maximum image quality. See tutorial prepared by Marc Andre D'Anjou available at the following link: https://www.youtube.com/watch?v=AxmR-hTVoN0

A figure legend must be provided for each figure and inserted into the main document (see below).

All patient identification information (name, medical record number, etc.) must be removed, blocked or masked in each figure.

Number all figures consecutively with Arabic numbers in order of appearance and insert a citation for each figure at the most relevant location in the text section of the main document. If figures are divided into components, insert a citation for each component at the relevant location in the text.

For labelling of figures with more than one image, please use the following format styles:

In figure: insert UPPERCASE letters enclosed in parentheses in each image In legends: use UPPERCASE letters, followed by a comma. Example: A, Histological section of... B, Comparison of...

In-text citations: use UPPERCASE letters and no space between number and letter. Example: Figure 1A, Figure 1A-C, Figures 2B and 2D

Figures must be submitted as separate individual files in non-compressed .tiff, high resolution EPS or .png format. Image figures must be at a resolution of 300 dpi. Image files should be created from original DICOM format files rather than converted from compressed jpg files. Graph or line drawing figures must be at a resolution of 600 dpi.

A single column figure will appear at a width of 3.34 inches and a double column illustration will appear with a width of 6.84 inches. Generally, figures are printed using single-column width. Authors should keep this size in mind and use cropping where possible to emphasize the main point for each figure.

Color figures can be included in printed versions of Veterinary Radiology & Ultrasound at an additional fee specified by Wiley. This fee is charged over and above the per page publishing fee. Online color reproductions are offered at no additional charge.

Authors may submit up to 2 video figures for a manuscript. Video files must clearly show a dynamic condition that cannot be adequately captured in still images. Video files must be submitted in MPEG-4 or Quicktime format and each file must be less than 5MB in size. The video files will accompany the online version of the manuscript only and a hyperlink reference for the video file will be provided in the print version of the paper. Video files will be downloadable from the Wiley Online Library.

Image orientation must be consistent with standard veterinary radiology conventions (click here for more information).

Authors are also asked to make their color figures as accessible as possible by avoiding the use of varying red and green colors. Some of our readers are color blind and may have difficulties distinguishing between these colors.

Figure legends must be included as part of the main word document; do not submit figure legends as a separate word document. Copy and paste the figure legend into the text box provided when the image is uploaded so that it will also be displayed under the image in the final pdf document.

When symbols, arrows, numbers, or letters are used to identify parts of the illustrations, identify and explain each one clearly in the legend.

Define any abbreviations used in figures or figure legends.

Explain the internal scale and identify the method of staining in photomicrographs.

Provide key technical and image acquisition parameters in the legend. (see details in the method guidelines above)

Radiographic images should be named according to the direction in which the central ray penetrates the part of interest, from point-of-entrance to point-of-exit. Appendices and Supporting Information

When essential for the understanding of the study, detailed information such as mathematical derivations, statistical analyses, and procedural descriptions may be presented in one or more appendices. Include in the appropriate section of the text (e.g., Materials and Methods, Results) a brief summary of the information contained in the Appendix and make reference to the corresponding Appendix in numerical order. Ex. Appendix 1. View Wiley's FAQs on supporting information.

1. Author Guidelines for Submitting to Orthopaedic Surgery Journal Clinical Article and Research Article

Full-length reports of current research in either basic or clinical science.

Word limit: no limit.

Abstract: about 400 words, structured (sub-headers): Objectives, Methods, Results, Conclusions.

References: no maximum.

Figures/tables: no limit. Style of the manuscript

Manuscripts must follow the style of the Vancouver agreement detailed in the International Committee of Medical Journal Editors' revised 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publication', as presented at: http://www.ICMJE.org/

• Spelling. The journal uses US spelling and authors should therefore follow the latest edition of the Merriam-Webster's Collegiate Dictionary.

• Units. All measurements must be given in SI or SI-derived units. For more information about SI units, please go to the Bureau International des Poids et Mesures (BIPM) website at: http://www.bipm.fr

• Abbreviations. Must be used sparingly – only where they ease the reader's task by reducing repetition of long, technical terms. Initially use the word in full, followed by the abbreviation in parentheses. Thereafter use the abbreviation only.

• Trade names. Drugs should be referred to by their generic names. If proprietary drugs have been used in the study, refer to these by their generic name, mentioning the proprietary name, and the name and location of the manufacturer, in parentheses.

Parts of the manuscript

The manuscript should be submitted in separate files: title page; main text file; figures.

Title Page

The title page should contain:

- The title of the paper. The title should be concise, informative and contain the major key words so that readers will discover the article easily in online searches. In general, abbreviations should not be used in the title. Titles that are too short may, however, lack important information, such as study design (which is particularly important in identifying randomized controlled trials). Authors should include all information in the title that will make electronic retrieval of the article both sensitive and specific.
- Running title. A short running title of less than 50 characters, and contain at least 2 informative key words. Abbreviations used in the text can be used in the running title
- The full names of the authors. Each author's given name should be followed by family name and capitalize your name in the same format as other papers in your publication history.
- The institutional affiliations of all authors at the time during which the work was carried out. The present address of any author, if different from that where the work was carried out, should be supplied in a footnote.
- The full postal and email address, plus facsimile and telephone numbers, of the author to whom correspondence about the manuscript should be sent.
- An authorship declaration. This must acknowledge i) that all authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and ii) that all authors are in agreement with the manuscript.
- Acknowledgements. This should include sources of support, including federal and industry support. All authors who have contributed to the manuscript must be acknowledged. Medical writers, proofreaders and editors should not be listed as authors but may be acknowledged here. Thanks to anonymous reviewers is not appropriate.
- Disclosure statement. Authors must declare any financial support or

relationships that may pose conflict of interest. For more detail refer to the section 'Disclosure' above.

Main text file

The length of papers should adhere to the guidelines outlined for each manuscript type in the 'Manuscript Categories and Length' section. As papers are double- blind peer reviewed the main text file should not include any information that might identify the authors.

The main text file should be presented in the following order: (i) abstract and key words, (ii) main text, (iv) references, (v) tables (each table complete with title and footnotes) and (vi) figure legends. Figures and supporting information should be supplied as separate files. Footnotes to the text are not allowed and any such material should be incorporated into the text as parenthetical matter.

Abstract

For Clinical Articles and Scientific Articles, abstract should be structured to include the following sections: objective (background for the study as well as the precise objective); methods (type of study and level of evidence, selection of patients, details on the intervention, outcome measures as well as other sufficient details of the method); results (significant data and observations); conclusions (principal conclusions that can help the readers understand the relevance of your findings). For Review Articles, the abstract should be an unstructured summary. For abstracts of other types of articles, please refer to the "Article Types" Section. The abstract must be factual and comprehensive. The use of abbreviations and acronyms should be limited and general statements (e.g. 'the significance of the results are discussed') should be avoided.

Keywords

Three to five key words should be supplied below the abstract, in alphabetical order, and should be taken from those recommended by the US National Library of Medicine's Medical Subject Headings (MeSH) browser list at: http://www.nlm.nih.gov/mesh/meshhome.html.

Text

The main text of Clinical Articles and Scientific Articles should be structured using the following sections: Introduction, Methods, Results, Discussion.

Introduction

The Introduction section should be 800-1500 words, and contain the background that motivated the study, problems that led to your undertaking the study, concise review of the most relevant literature. Conclude the introduction by stating the purpose of the study and then stating your hypothesis. A structured introduction is required.

Methods

The Methods section should include the study design and setting, participants/study subjects, description of experiment, treatment or surgery, data sources, statistical analysis and other details relevant to the conduct and interpretation of the study.

Results

The Results section should describe in detail the data obtained during the study. Avoid undue repetition of data in text and table. Brief comments on the significance of the results are appropriate, but broader aspects of interpretation are reserved for discussion. Use of subheadings to aid clarity is encouraged.

Discussion

The Discussion section should define the unanswered questions related to the topic, discuss the findings in context of relevant published data and provide clear directions for future research. A section on limitations of the study is often recommended.

Acknowledgments

Contributions from individuals who do not meet the criteria for authorship should be listed, with permission from the contributor, in an 'Acknowledgments' section. Financial and material support should also be mentioned. Thanks to anonymous reviewers are not appropriate.

Authors' Contributions

Click here for

instructions Ethical

Statement

All eligible articles should have an explicit statement that includes information on ethical approvals and consent to participate and publish.

References

• The Vancouver system of referencing should be used (examples are given below).

• In the text, references should be cited using superscript Arabic numerals in the order in which they appear.

• If cited in tables or figure legends, number according to the first identification of the table or figure in the text.

• In the reference list, cite the names of all authors when there are six or fewer; when seven or more, list the first three followed by et al.

• Do not use ibid. or op cit.

• Reference to unpublished data and personal communications should not appear in the list but should be cited in the text only (e.g. Smith A, 2000, unpublished data).

• All citations mentioned in the text, tables or figures must be listed in the reference list.

• Names of journals should be abbreviated in the style used in Index Medicus.

• Authors are responsible for the accuracy of the references. Examples of references:

Journal article

1. Gibas Z, Prout DF Jr, Pontes JR. Chromosome changes in germ cell tumours of the testis. Cancer Genet Cytogenet. 1986, 19: 254-252.

Online article not yet published in an issue An online article that has not yet been published in an issue (therefore has no volume, issue or page numbers) can be cited by its Digital Object Identifier (DOI). The DOI will remain valid and allow an article to be tracked even after its allocation to an issue.

2. Kengne Ap, Nakamura K, Barzi F, et al. Smoking, Diabetes and cardiovascular diseases in men in the Asia-Pacific Region. J Diabetes 2009; doi: 10.1111/j.1753- 0407.2009.00028.x

Book

3. Ernstoff M. Urologic Cancer. Blackwell Science, Boston, 1997:132-154. Chapter in a Book

4. Gilchrist RK. Further commentary: Continent stroma. In: King LR, Stone AR, Webster GD (eds). Bladder Reconstruction and Continent Urinary Diversion. Year Book Medical, Chicago, 1987; 204-205.

Electronic material

5. Cancer-Pain.org [homepage on the internet]. New York: Association of Cancer Online Resources, Inc.; c2000-01 [Cited 2015 May 11]. Available from: http://www.cancer-pain.org/.

Tables

• Tables should be self-contained and complement, but not duplicate, information contained in the text.

• Number tables consecutively in the text in Arabic numerals.

• Type tables on a separate page with the legend above.

• Legends should be concise but comprehensive – the table, legend and footnotes must be understandable without reference to the text.

• Vertical lines should not be used to separate columns.

• Column headings should be brief, with units of measurement in parentheses; all abbreviations must be defined in footnotes.

• Footnote symbols: †, ‡, §, ¶, should be used (in that order) and *, **, *** should be reserved for P-values.

• Statistical measures such as SD or SEM should be identified in the headings.

• If tables have been reproduced from another source, a letter from the copyright holder (usually the Publisher), stating authorization to reproduce the material, must be attached to the covering letter.

Figure legends

Type figure legends on a separate page. Legends should be concise but comprehensive – the figure and its legend must be understandable without reference to the text. Include definitions of any symbols used and define/explain all abbreviations and units of measurement.

Figures

• All illustrations (line drawings and photographs) are classified as figures.

• Figures should be cited in consecutive order in the text.

• Magnifications should be indicated using a scale bar on the illustration.

• Size. Figures should be sized to fit within the column (82 mm), intermediate (118 mm) or the full text width (173 mm).

• Resolution. Figures must be supplied as high resolution saved as .eps or .tif. Halftone figures 300 dpi (dots per inch), color figures 300 dpi saved as

CMYK, figures containing text 400 dpi, Line figures 1,000 dpi.

• Color figures. Files should be set up as CMYK (cyan, magenta, yellow, black) and not as RGB (red, green, blue) so that colors as they appear on screen will be a closer representation of how they will print in the journal.

More advice on figures can be found at Wiley's guidelines for preparation of figures: http://authorservices.wiley.com/bauthor/illustration.asp

Equations

Equations should be numbered sequentially with Arabic numerals; these should be ranged right in parentheses. All variables should appear in italics. Use the simplest possible form for all mathematical symbols.

Graphical abstracts

Orthopaedic Surgery publishes graphical abstracts for each article, displayed online in graphical form with a brief abstract (in addition to the <250 word abstract above).

The online table of contents will display a schematic figure to convey the core message of your paper, alongside a short abstract highlighting the major findings of the paper. Authors should submit a new and stand-alone image, not already included in the paper. Your graphical abstract should be simple, colourful and contain minimal text to attract additional readers. Your short abstract should consist of 2-3 sentences (max 500 characters with spaces) summarising the key findings presented in the paper. Graphical abstract entries should be submitted to Scholar One in one of the generic file formats and uploaded as 'Graphical Abstract' during the initial manuscript submission process. The image should be supplied as a tif or a pdf and fit within the dimensions of 50mm x 60mm and be fully legible at this size.

Supporting Information

Supporting information is not essential to the article but provides greater depth and background and may include tables, figures, videos, datasets, etc. This material can be submitted with your manuscript, and will appear online, without editing or typesetting. Guidelines on how to prepare this material and which formats and files sizes are acceptable can be found at: http://authorservices.wiley.com/bauthor/suppmat.asp

Please note that the provision of supporting information is not encouraged as a general rule. It will be assessed critically by reviewers and editors and will only be accepted if it is essential.

Article Preparation Support

Wiley Editing Services offers expert help with English Language Editing, as well as translation, manuscript formatting, figure illustration, figure formatting, and graphical abstract design – so you can submit your manuscript with confidence. Also, check out our resources for Preparing Your Article for general guidance about writing and preparing your manuscript.

fmvz - unesp

Faculdade de Medicina Veterinária e Zootecnia
Campus de Botucatu

ATESTADO

Atesto que o Projeto "Ocorrência de Kissing Spines nos segmentos torácico e lombar da coluna vertebral de equinos de trabalho no território nacional, que executam várias modalidades equestres, por meio do exame radiográfico digital." **Protocolo CEUA 0005/2022** , a ser conduzido por Marco Aurélio Gallo, responsável/orientador Vânia Maria de Vasconcelos Machado, para fins de pesquisa científica/ensino - encontra-se de acordo com os preceitos da Lei nº 11.794, de 08 de outubro de 2008, do Decreto nº 6.899, de 15 de julho de 2009, ecom as normas editadas pelo Conselho Nacional de Controle de Experimentação Animal - CONCEA.

Finalidade	PESQUISA CIENTÍFICA
Vigência do projeto	04/04/2022 a 30/06/2024
Nome Comum / Espécie /Linhagem	EQUINA / EQUUS CABALLUS /
Raça	P. S. Inglês, Quarto de Milha e P. S. Árabe
Nº de animais machos	30
Nº de animais fêmeas	30
Nº de animais sexo indefinido	0
Peso médio de animais machos	400kg
Peso médio de animais fêmeas	400kg
Peso médio de animais sexoindefinido	0
Idade	2 ano(s) e 0 mes(es) e 0 dia(s).
Procedência	Estado de São Paulo de criatórios particulares

Projeto de Pesquisa aprovado em reunião da CEUA em 19/01/2022

JULIANY GOMES QUITZAN

Presidente da CEUA da FMVZ,
UNESP - Campus de
Botucatu

Faculdade de Medicina Veterinária e
Zootecnia Seção Técnica
Acadêmica
Rua Prof. Dr. Walter Mauricio Corrêa, s/n UNESP - Campus de Botucatu/SP - Cep 18618-681
(14) 3880-2176 - patrizia@fmvz.unesp.br - www.fmvz.unesp.br