# The development of the dynamic balance in foals from birth till twelve weeks of age.

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## *Abstract*

This study was set up to determine how foals develop dynamic balance during walk and trot in the first twelve weeks of life and to determine whether a correlation exists with the development of OC. To objectively quantify the development of dynamic balance during walk and trot in foals, eleven sound Dutch Warmblood foals bred for show jumping were led at walk and trot over a dynamically calibrated pressure plate to collect kinetic data. The nPVF and CV of the nPVF were used to evaluate the kinetics and between the age of 4 and 6 weeks radiographs were made of the hock. We expected that over time the foals will become more stable, which is reflected by a decrease in the variation of nPVF between different trials and thus a lower CV. The results show that the foals develop no dynamic stable balance visible in the kinetics and the results show a higher mean nPVF in walk for OCD- compared with OCD+. Furthermore we expected that the presence of OC lesions lead to a temporary reduction of the nPVF.  This indicates that the foals put less load on the affected limb and show no lameness by physical examination, but have a subclinical lameness.



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## Introduction

Foals are precocious animals as they are able to stand and follow their dam within a few hours after birth. [Nauwelaerts et al., 2013; Van Heel et al., 2006]. Although able to walk, their gait is still hypermetric and uncoordinated after birth. The lack of balance is reflected by the splaying of the limbs, to compensate for poor balance in the latero-medial plane. To maintain balance during stance and locomotion, postural control is necessary [Clayton et al., 2012]. The maturation of the musculoskeletal system, the neuromuscular reflexes and the interaction between both systems are important to acquire postural control [Massion et al., 1992; Nauwelaerts et al., 2013]. During the first weeks of life till weaning the foals show an increase in muscle tone and increased coordination, which result in corrections of the hypermetric and uncoordinated gait and development of the control of flexor and extensor musculature [Nauwelaerts et al., 2013; Robert et al., 2013].

Not only the neuromuscular and musculoskeletal systems are important for postural control and coordination. Also sensory information is necessary. Riach et al., 1994, investigated the pattern of the development of postural control in children. They suggest that young children function predominantly in an open-loop neuromuscular system, and during development they switch to using predominantly a closed-loop neuromuscular system. This is possible through the development of the neuromuscular and musculoskeletal system, whereby visual, vestibular and somatosensory information integrates in these systems. The difference between the open-loop system and closed-loop system is that the open-loop system consists of vast ballistic corrections and closed-loop systems are sensory monitored. Due to the fact that the closed-loop system is sensory monitored, the neuromuscular and musculoskeletal systems react more slowly. In cases where faster reaction is needed it would be more useful to revert back to the open-loop system [Riach et al., 1994]. Foals are prey animals and therefore they are very responsive to external stimuli and react fast to these stimuli to use the open-loop system. Children learn between the age of 4 and 6 years how to integrate sensory information and how to calibrate sensory feedback for use in postural control [Riach et al., 1994]. Foals, with their incomplete neuromuscular reflexes, weak musculature and inexperienced postural control, rely on open-loop control, but over the first two weeks they learn to integrate sensory input and in the following months they change to a closed-loop mechanism [Nauwelaerts et al., 2013]. The foals learn much earlier and quicker than children how to integrate the sensory information and how to calibrate sensory feedback for use in postural control, and they stand much earlier unaided and move in a coordinated manner. To quantify the postural balance Nauwelaerts et al., 2013, studied the changes in stabilographic variables during standing in foals from birth to 5 months of age. They found that during the first weeks of age the variables of the swaying amplitude and velocities decreased more rapidly and over the following weeks and months more slowly due to the improvement of the neuromotor control and muscular strength [Nauwelaerts et al., 2013]. These findings suggest that the dynamic balance develops in de same way as the stabilographic variables.

Osteochondrosis (OC) is a frequent lameness and one of the most common development orthopedic diseases in young horses [Dik et al., 1999]. OC is a multifactorial disease and factors which possibly contribute to the expression of OC are biomechanical influences and trauma. Osteochondrosis can cause lameness and influence the gait of the horses. Therefore, it is important to know whether foals have OC lesions or not and if it is related to the changes in kinetics during growth. Dik et al., 1999, monitored the early development of osteochondral abnormalities in the stifle and hock of Dutch Warmblood foals. They found several changes related to OC in radiographs of the stifle and hock in foals 1 and 11 months of age. It is a dynamic condition as these lesions develop, stay stationary, progress and stay permanent or regress [Dik et al., 1999]. Over time the lesions change and it is possible that these changes occur under the influence of the changing kinetics due to the developing postural balance. Trauma is a factor which contributes to the expression of OC. Since foals have a poor postural control and coordination and make unexpected movements in the first weeks of life, this imbalance could lead to an irregularity in the amount of weight allocated to each limb and this can cause trauma and the start of an OC lesion. At this moment no research is available about the effect of the limbloading on the development of OC lesion. Another factor contributes to the development of OC are biomechanical influences. The biomechanical influences differ during growth, because of the changes in the kinematics of the limbs due to growth. During growth the height at the withers change and these changes are responsible for changing stride length and increasing or decreasing flexion or extension of the limbs [Cano et al., 2001]. So, this indicates that conformational changes are responsible for changes in kinematics; and therefore, the kinetics change. This was found by Meijer et al., 2014. They also found a significant variability between-session for kinetic data in growing piglets even though the kinetic data were corrected for body mass [Meijer et al., 2014]. At this moment it is unclear whether the biomechanical changes influences the development of OC lesions during growth.

To evaluate the kinetic gait variables in horses a pressure plate or a force plate can be used. Meijer et al. 2014, studied the kinetic gait data in pigs by using a pressure plate [Meijer et al., 2014] and Oosterlinck et al., 2010a, studied the dynamic evaluation of limb-loading in adult horses by using a pressure plate [Oosterlinck et al., 2010a]. With the pressure plate it is possible to collect several types of data about the kinetic gait variables. One of these parameters is de peak vertical force (PVF). Ishihara et al., 2005, found that the PVF has the highest specificity and sensitivity for lameness [Ishihara et al., 2005] and the PVF is one of the parameters that show the force distribution within each hoof [Meijer et al., 2014]. The PVF can demonstrate the changes and variations between every trial and every measure moment. The intra-individual variability can be demonstrated with the coefficient of variation (CV) of the PVF. Oosterlinck et al., 2011, showed by using the CV that horses with relatively symmetrical hooves had low intra-individual variability by dynamic hoof contact area measurements [Oosterlinck et al., 2011]. Oosterlinck et al., 2010a, concluded that a low CV indicates an excellent repeatability [Oosterlink et al., 2010a]. In young foals more balance incoordination during locomotion can be expected compared to adult horses. This imbalance could lead to an irregularity in the amount of weight allocated to each limb. This is in agreement with Nauwelaerts et al., 2013. They found by observing the stabilographic analysis of young foals that a suboptimal postural balance was characterized by larger velocities and swaying amplitudes

[Nauwelaerts et al., 2013]. Ishihara et al., 2009, used the same method to diagnose spinal ataxia, a pathology leading to an "imbalanced gait" [Ishihara et al., 2009]. Furthermore, variability of kinematic gait parameters was used to quantify maturation of gait in toddlers (Clark et al. 1988) and warmblood foals (Back et al. 1994).

The aim of this study was to analyze kinetic data to determine the development of the dynamic balance during walk and trot in foals from birth to 12 weeks of age by using a pressure plate, and to determine whether a correlation exists with the development of OC.

We expected that over time the foals will become more stable, which is reflected by a decrease in the variation of nPVF between different trials and thus a lower CV. Furthermore we expected that the presence of OC lesions lead to a temporary reduction of the nPVF.

## Material and Methods

*Foals*

For this study an experimental group of eleven sound Dutch Warmblood foals bred for show jumping were included. The group consisted of 5 mares and 6 stallions. All foals were born and raised in 2014 in the Netherlands at the same breeding stable. The eleven foals had a normal gestation and parturition and were kept under the same conditions. All foals were born in a stable. In the first days the dam and foal were put on pastures during the day depending on the weather. A few days later the dam and foal were put on pastures during the days as well as during the nights. During the study (from day 0 to the age of 12 weeks) the foals and dams were kept together in the pasture and stabled during the night.

The measurements were performed at the stud farm during the first three days after birth and then at an age of 1, 2, 4, 6, 8, 10 and 12 weeks after birth. During the first and the second measurements the foals only had to walk on the pressure plate. All the other moments of measuring, the foals had to walk and trot on the pressure plate. Before the measurements the foals underwent a physical examination and an examination of the locomotion/ gait. Foals were included only if they were considered healthy and sound.

*Measurement system and data collection*

For each measurement session the weight of the foals was calculated with the formulas of Stanier et al., 2004 [Stanier et al., 2004].

The foals were led first at walk and subsequently at trot over the pressure plate (Footscan® 3D Gait Scientific 2 m system, RSscan International, Olen, Belgium). The pressure plate was connected to a laptop with specialized software (Footscan Scientific Gait 7 gait 2nd generation, number 799, RSscan International, Olen, Belgium). Calibration of the pressure mat was performed according to the manufacturer's instructions using a person weighing 85 kg. The pressure plate was laid down on the ground and surrounded by two wooden planks with the same height as the pressure plate. Due to the wooden planks the walkway was widened. At the beginning and end a wooden plank with a slope was put down so the foals wouldn't have to step on an elevation. The whole track was covered with a 5-mm-thick and 10m long rubber mat. The location of the pressure plate (under the rubber mat) was marked by tape on the rubber at the position of the corners of the pressure plate. On one side of the track there was a wall, and the foals were guided by hand. At all times the mare was also guided by hand and walked next to the plate so the foal would follow the mare. After a short warming up period to get the foals used to the situation, the measurements started.

*Inclusion criteria*

A trial was considered valid if the foal moved at a constant pace, looked straight ahead, walked in a normal way on the plate and a complete hoof print from two or more limbs were recorded. To see if a trial was considered valid videos were made during every trial to record how the foal walked across the pressure plate. The videos were also used for later determination of which print is which hoof. For data processing five valid trials of each hoof were collected.

Between the age of 4 and 6 weeks radiographs were made of the hock. The radiographs were taken after sedation of the foal. In total five radiographs were taken, two (latero-medial and lateral-cranio-medial-oblique) from the femorotibial and femeropatellar joints and three (latero-medial, anterior-posterior and dorsomedial-palmarolateral oblique) from the tarsocrural joints. Two board-certified veterinary radiologists evaluated the radiographs for OCD lesions and gave a positive or negative score.

*Data processing*
Of every trial hoof strikes were manually assigned to left forelimb (LF), right forelimb (RF), left hind limb (LH) and right hind limb (RH). To match the hoof prints to the same hoof, the videos were used. After determining the hoofs the results from Footscan Scientific Gait 7 gait 2nd generation were saved and exported to Microsoft Excel.

The nPVF of five valid trials of each hind limb (five of the left hind and five of the right hind) of each foal is taken together to calculate the mean of the hind limbs (left and right together) of each foal. For every week the nPVF of the average of every foal in the OCD+ group is taken together to calculate the mean and the standard deviation (SD) for that week of these foals. This is also done for the foals in the OCD- group. These data are used to calculate the intra variability of the nPVF in the OCD+ and OCD- group. The intra variability was calculated as the coefficients of variation (CV): SD/mean x 100%. The CV of each foal (OCD+ or OCD-) for every week is taken together to calculate the mean (and the SD). The nPVF (with SD) and de CV (with SD) will be presented in a bar chart.

*Statistical analysis*
An independent sample T-test was used to evaluate the difference between the OCD+ and OCD- groups for nPVF and CV of both hindlimbs in walk and in trot. Data were collected and prepared for statistical analysis using Microsoft Excel software. For statistical analysis SPSS statistics 22 was used. To achieve a normal distribution a logarithmic transformation of PVF was performed.

## Results

*Foals*
During the measurement period the foals were considered healthy and sound.

*Growth of the foals*
The height at the withers increase till week 8 and after week 10 (fig. 10). Between week 8 and 10 there is a little increase of the height at the withers compared with the other weeks. The weight of the foals increase during the first 12 weeks after birth (fig. 1). Between week 2 and 10 the increase is the same.

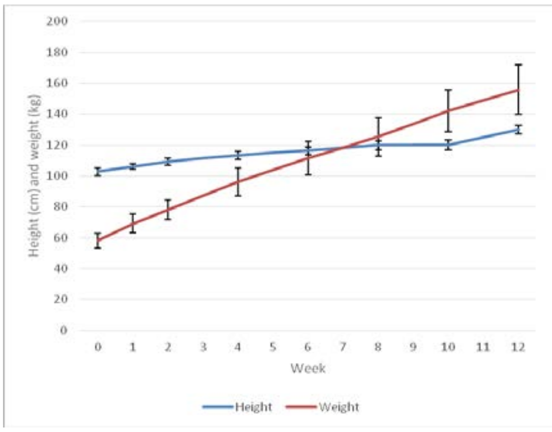


Fig. 1 The mean height at the withers (cm) and the mean weight (kg) of all foals during the first 12 weeks after birth.

*Radiographic scores for OCD*
Table 1 shows the radiographic scores of the tarsal joint for OCD lesions at an age of 4 till 6 weeks. Six foals were positive for OCD lesions in one or both hindlimbs (OCD+) and five foals were negative for OCD lesions (OCD-).
After the radiographs the foals were divided into two groups: OCD+ and OCD-. The foals in the OCD+ group have a positive score for OCD lesions on the radiographs in one or both hindlimbs. The foals in the OCD- group have a negative score on the radiographs for OCD lesions.

| | RH | LH |
|---|---|---|
| **Foal 1** | - | - |
| **Foal 2** | + | + |
| **Foal 3** | + | - |
| **Foal 4** | - | - |
| **Foal 5** | + | - |
| **Foal 6** | + | + |
| **Foal 7** | + | + |
| **Foal 8** | - | - |
| **Foal 9** | - | - |
| **Foal 10** | - | - |
| **Foal 11** | - | + |

*Table 1: Scores for OCD for the hockjoint of each hindlimb in week 4-6 (+ means positive for an OCD lesion and – means negative for an OCD lesion).*

*Velocity*

Fig. 2 shows the mean velocity of all foals in walk and in trot during the first twelve weeks after birth. The velocity shows an increase during the first 12 weeks after birth. In walk there is a little decline visible at week 6 and these decline is not visible in trot. In trotthere is a decline visible at week 12.

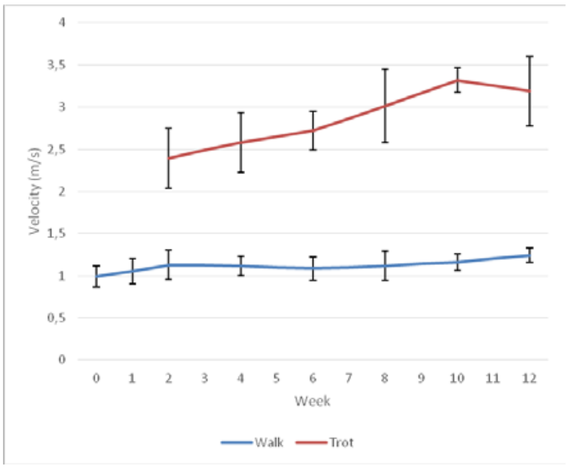


Fig. 2. Mean velocity (m/s) of all foals during the first 12 weeks after birth at the walk and trot.

*nPVF and CV of the nPVF*

Figure 3 shows the nPVF in walk for OCD+ and OCD- of the hindlimbs. The mean nPVF of the OCD- foals is higher than the mean nPVF of the OCD+ foals. This is seen in all measurement moments except for week 10. The SD changes between the weeks for the OCD- foals, there is no 'line' of decrease or increase visible. For the OCD- foals the SD is higher in comparison with the OCD+ foals. The difference between the weeks was not significant for the nPVF in walk, except for week 8-10 for OCD- and OCD+.

Figure 4 show the average of the CV for both hindlimbs of the six foals of OCD+ group and the five foals of the OCD- group. The CV of the nPVF is higher for OCD- than for OCD+. For OCD+ the CV of the nPVF is almost the same from week 4. For week 2 there is a decline visible for OCD- and OCD+. From week 2 till week 10 the CV of the nPVF for OCD- increases. Before week 6 the mean CV of the nPVF for OCD- and OCD+ variates and in week 12 both show a decline. So, one week the CV of the nPVF for OCD+ is higher than for OCD- and the other week the CV of the nPVF for OCD- is higher than for OCD+. The SD of the CV of the nPVF shows a great variation over the time for both OCD+ and OCD-, but from week 8 the SD is higher for OCD+. The difference between weeks was not significant for the CV in walk, except for week 0-1, 1-2 and 2-4 for OCD-.

The average hindlimb nPVF in trot for OCD+ group and OCD- group is show in figure 5. Except for week 10 a higher mean of the nPVF for OCD- is visible in comparison with the nPVF for OCD+. This is also seen in walk. Overall the SD for OCD- is higher than the SD for OCD+ and the SD in trot changes more over the time for OCD+ in comparison with the SD in walk. The difference between weeks was not significantfor the nPVF in trot, except for week 8-10 for the OCD- group.

The CV of the nPVF for OCD+ is higher than for OCD – in week 4 and week 6 (fig. 6). The other weeks the CV of the nPVF for OCD+ is lower than for OCD+. From week 8 the CV of the nPVF for OCD- increase more than for OCD+. For the CV of the nPVF of OCD+ the mean of the CV is almost the same for week 10 and 12. The SD shows more variation till week 8 for both OCD+ and OCD-. From week 10 the SD is almost the same for OCD+ and OCD-. The difference between weeks group was not significant for the CV in trot.

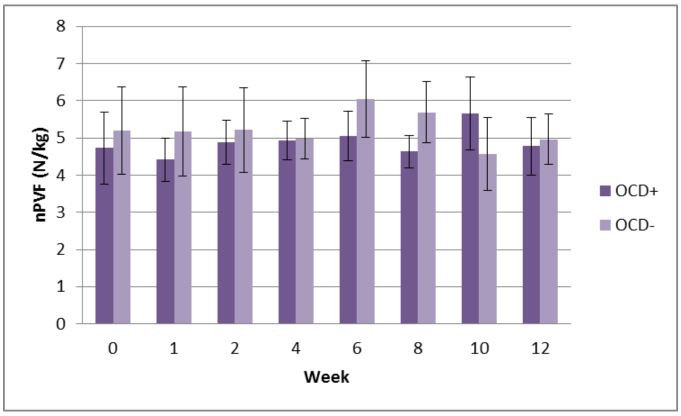


Fig. 3 Average hindlimb nPVF in walk of the foals positive for OCD lesions for one of both hindlimbs (OCD +) and the nPVF in walk of the foals negative for OCD lesions for both hindlimbs (OCD-).

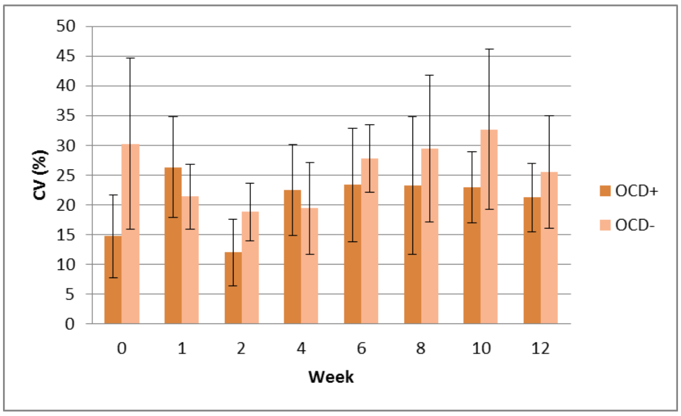


Fig. 4 CV of the nPVF of foals with OCD+ or OCD- score of the hindlimbs in walk**.**

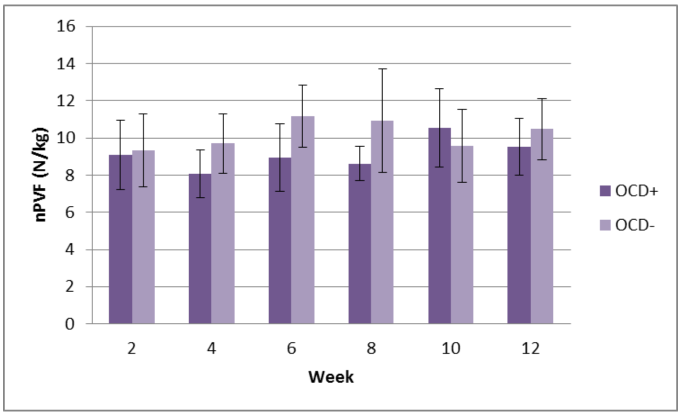


Fig. 5 Average hindlimb nPVF in trot of the foals positive for OCD for one of both hindlimbs (OCD +) and the nPVF in trot of the foals negative for OCD for both hindlimbs (OCD-).

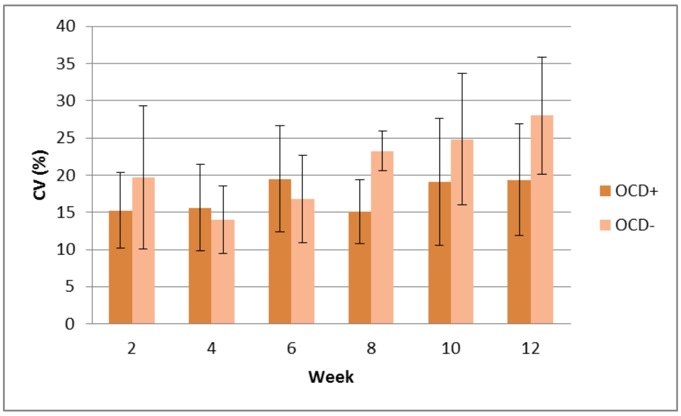


Fig. 6 CV of the nPVF of foals with OCD+ or OCD- score of the hindlimbs in trot.

## Discussion

This study was set up to determine how foals develop dynamic balance during walk and trot in the first twelve weeks of life. The results show that the foals develop no dynamic stable balance visible in the kinetics. It is known in adult horses that they land in the same manner every time with the same force on each limb [Oosterlinck et al., 2011], but this differs with different surfaces [Oosterlinck et al., 2013a]. So on a specific surface horses develop a specific stable pattern to land and it is reasonable that the foals during their development get their adult-like walk pattern. This pattern is not visible in first 12 weeks of life.

For the evaluation of the kinetics the nPVF and the CV of the nPVF were used. The nPVF is one of the parameters often used in force plate and pressure plate analysis and the most relevant kinetic parameter in equine gait evaluation [Oosterlinck et al., 2010a].Here, the nPVF is a parameter which is useful in distinguishing lameness and subclinical lameness, because it shows little differences in force distribution within each hoof. [Meijer et al., 2014; Oosterlinck et al., 2010a]. Therefore it is useful for the evaluation of the effect of OCD lesions, because it is known that an OCD lesion not always results in a clinical lameness in foals [Dik et al., 1999]. The nPVF is the PVF normalized for bodyweight and takes into account that foals increase in weight. In spite of the normalization of the nPVF there is an increase visible in the nPVF during the measurement period. It is known that the nPVF is influenced by velocity [Meijer et al., 2014; Oosterlinck et al., 2011; Oosterlinck et al., 2010a] An increase of the velocity results in an increase in nPVF [Khumsap et al., 2002]. Meijer et al., 2014, suggest that conformational changes influences the kinetic data, but the direction of this influence differed between weeks [Meijer et al., 2014]. The kinetic data cannot be corrected for the changes in kinematics due to conformational changes [Meijer et al., 2014]. Subsequently, the velocity and the conformational changes due to growth influences the kinetic data in this study.

Another parameter is the CV of the nPVF. The CV compared the SD with the mean and described the inter- and between trial variability and it is useful to see the variability between the average of the several measurements over a period of 12 weeks. Oosterlinck et al., 2011, used the CV to assess inter-individual variability in the fore and hind limbs [Oosterlinck et al., 2011] and Foss et al., 2013, used the CV of the PVF to compare dogs with cervical spondylomyelopathy with healthy dogs [Foss et al., 2013]. Oosterlinck et al., 2011, showed by using the CV that horses with relatively symmetrical hooves had low intra-individual variability by dynamic hoof contact area measurements [Oosterlinck et al., 2011]. In another study in ponies the mean CV within trials was moderate (< 14%) for walk and low (<10 %) for the trot [Oosterlink et al., 2010a]. In our study the CV in walk is more than 20% except for week 0 and 2. The CV in trot is more than 15% except for week 4 of the OCD- group. Oosterlinck et al., 2010a, found that a low CV indicates for an excellent repeatability [Oosterlinck et al., 2010a]. Our results show that the foals do not have an excellent repeatability and thus no excellent dynamic balance, because of a high CV compared with the findings of Oosterlinck et al., 2010a. But the results of our study indicate that the dynamic balance is better in trot compared to walk. Foss et al., 2013, compared affected and healthy dogs by using the CV. They suggest that the CV is not useful clinically for discrimination between mildly affected dogs and healthy dogs. [Foss et al., 2013]. Therefore it is doubtful whether the CV is a usefull parameter in this study, because of the fact that the foals show no clinical lameness at physical examination. So, the variation between foals with OCD lesions and without OCD lesions is less. Furthermore, the findings of Dik et al., 1999, show that the OCD lesions change till 8 months and here is only the lesion know at an age of 4-6 weeks [Dik et al., 1999]. The CV compared several trials and after several trials foals became tired. Wickler et al., 2006 found that the stride lengths increase and the stride frequencies decrease in fatigue [Wickler et al., 2006]. It is reasonable that changes in stride lengths and stride frequencies influences the velocity and the velocity influences the nPVF. Furthermore Higham et al., 2009, found that the peak force generation was more variable (measured by the CV) for fatigued animals [Higham et al., 2009]. So, fatigue influences the measurements and the videos show that the foals gained more stamina when they grew older during the study, also probably because of getting used to being lead by handlers and developing a better body condition. So it is reasonable that fatigue influenced the parameters less when the foals became older, but sometimes the foals were playful and this can influence the measurements. If all these factors influence the CV by influencing the nPVF the CV is maybe not the right parameter for the measurement of the dynamic balance.

In this study, we only looked at the nPVF and the CV and both parameters were influenced by several factors (conformational changes, velocity, fatigue and landing surface). That the balance of the foals improves is showed by Nauwelaerts et al., 2014. They show that foals are unable to stand fully in balance during the first weeks of life, but improves during the following weeks. They also found that the foals walk hypermetric during the first week and this disappears after the first week. [Nauwelaerts et al., 2014]. So, maybe the foals develop some dynamic balance during the first 12 weeks of life, but the nPVF and the CV may not be sufficient parameters.

To collect the data a pressure plate is used, but a force plate can also be used. For the objectively evaluation of kinetic gait variables a force plate is the golden standard [Meijer et al, 2014]. A force plate can be used only under laboratory environments, which makes it not portable and, because of that, a costly way of measuring [Oosterlinck et al., 2010b]. The pressure plate is portable and this make it possible to do the measurements at location. Due to ethical and logistic considerations measurements took place at location, which limited us to using a pressure plate. Another advantage of the pressure plate is that the pressure plate can record more than one limb every run, reducing the number of trials necessary to collect five valid hoof strikes of each limb, which is advantageous for foals that tire quickly [Meijer et al., 2014]. Oosterlinck et al., 2010a, found that the pressure plate can be used for the objective and dynamic evaluation of limb-loading [Meijer et al., 2014; Oosterlinck et al., 2010a]. Previous research shows that the pressure plate gives a lower frequency than a force plate [Meijer et al., 2014; Oosterlinck et al., 2010b]. If high accuracy of absolute force values is needed for scientific purposes, a force plate cannot be replaced by a pressure plate [Oosterlinck et al., 2011]. The pressure plate is less accurate, but the measurements are always with the same pressure plate on the same manner. Due to this there can be looked at ‘trends’ during time spans. Errors due to measurement mistakes will be less visible because they were always the same.

The development of the coordination of foals is significantly influenced by exercise regimes [Back et al., 1999]. Van Weeren et al., 1999, suggest some effect of exercise on the clinical manifestation of OCD lesion through biomechanical loading. They found that there is no influence of exercise regimes during the first months of life on the number and severity of OC lesions, but there are indications that the localizations and manifestation of lesions may be influenced by exercise [Van Weeren et al., 1999]. So, it is interesting for further research if exercise regimes influences the moment of development of a stable gait and the influence of exercise regimes on the development of OCD lesions.The results show a higher mean nPVF in walk for OCD- compared with OCD+. This indicates that the foals put less load on the affected limb and show no lameness by physical examination, but have a subclinical lameness. This is similar with the findings of Meijer et al., 2014, and Oosterlinck et al., 2010a. They found that the pressure plate can be used to distinguish lameness in horses, before they show lameness at physical examination. They suggest that the pressure plate can be used to find lameness in horses [Meijer et al., 2014; Oosterlinck et al., 2010a Dik et al., 1999, found that abnormal radiographic presentations for OCD lesions were relatively common at an age of 1 month and that the majority of these abnormal radiographic findings gradually disappeared. Normal radiographic findings of the joints rarely develop into abnormal radiographic findings. [Dik et al., 1999]. Furthermore Dik et al., 1999, described a point of no return for OCD lesions in foals. The point of no return is between 5 and 8 months of age and they suggest that screening for OCD before 8 months of age are contra-indicated because of the point of no return [Dik et al., 1999]. Due to this it is doubtful of the screening  trough radiographs for OCD lesions in foals is reliable because of the changing character of the OCD lesion during the first months of life. Our results show a small change in kinetic data for the foals in the OCD+ group compared with the foals in the OCD- group. So, this indicates a subclinical lameness and screening with a pressure plate is can be useful. In this study there is not looked if foals have unilateral or bilateral OCD lesions.

For the statistical evaluation a non-parametric test, because of the fact that the data are not normally distributed and the sample size is very small. The disadvantages of this test is that the results of earlier weeks were not used in the subsequent analysis; in other words, subsequent analyses are new, which means that a foal can have any result and the chance is the same for every result. However, if a foal has a high nPVF it will have a high nPVF every week. Probably a linear Mixed Effects Model is better in this study for the statistical evaluation of the data.

When the foals become dynamicly more in balance the variation of the force on each limb during each trial and each measurement will decline, which is not visible in the results. The results show differences between the OCD+ group and the OCD- group, but it is unclear if the foal gets an OCD lesion due to the fact that they walk dynamicly unstable or there is another reason for the development of the OCD lesion. So, the results show that an OCD lesion results in a subclinical lameness. To get better results of the dynamic balance, another parameter may be used. For the screening of OCD lesions the pressure plate is useful, but it is not necessary because of the fact that the OCD lesions continue, disappear or progress.

The study was approved by the Ethical Committee of the Faculty of Veterinary Medicine, Utrecht University.

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