Valvular regurgitations, heart murmurs and cardiac dimensions in elite dressage horses

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1. Abstract

OBJECTIVE: To assess the characteristics of heart adaptation and the prevalence of valvular regurgitation and heart murmurs in elite dressage horses.

ANIMALS: 15 fit elite (competing at Z2 level and higher) dressage horses and 15 untrained warmblood horses.

METHODES: All horses underwent a physical examination, cardiac auscultation and B-Mode, M- Mode and Colour Flow Doppler echocardiography. Dressage horses were further classified by training intensity and competition level to determine possible intensity effects.

RESULTS: Healthy and fit dressage horses had a higher prevalence of valvular murmurs of the aorta, mitral and tricuspid valve than horses that were not trained. Also the prevalence of valvular regurgitations of the aorta, mitral and tricuspid valve detected with Doppler echocardiography was higher in the dressage group than in the control group. Right ventricle diameter (RVD), interventricular septum in diastole (IVSd), pulmonary artery diameter (PAD), calculated left ventricle mass (LVmass) and mean wall thickness (MWT) were significantly higher in dressage than control horses. Competition level groups (control, Z2 & ZZ and ≥Prix Saint Georges) differed in IVSd, left ventriculair posterior wall in diastole (LVPWd), E-point to septal separation (EPSS), PAD, LVmass and MWT while training level groups differed in IVSd, LVPWd, EPSS, LVmass and MWT.

CONCLUSION: This group of dressage horses did show left sided heart changes especially wall thickness adaptation and showed a higher prevalence of audible murmurs and valvular regurgitations than controls horses.

2. Introduction

Much research has been conducted in the past on cardiovascular adaptations in horses resulting from training. However, virtually all of this research has been limited to standardbred trotters and thoroughbreds. There are only a few scattered studies on training-related cardiovascular adaptations in warmblood horses.

Past research on standardbred trotters has shown that training leads to an increase in left ventricular internal diameter (LVID), left ventricular myocardial mass (LV mass) and mean wall thickness (MWT).[3,4] Similar studies have been conducted on thoroughbreds, which also found an increase in left ventricular internal diameter (LVID), left ventricular myocardial mass (LV mass) and mean wall thickness (MWT).[15,16] Additionally, racehorses also show a decrease in the abovementioned dimensions after a sufficiently long period of deconditioning.[16]

A distinction can be made in the way in which horses are trained. The two extreme components in terms of training focus are the component of endurance on the one side and the component of strength on the other side. In standardbred trotters, which are trained almost exclusively in endurance, an increase is seen in mean thickness (MWT) and left ventricular internal diameter (LVID), while relative wall thickness (RWT) remains unchanged for this group.[4] In racehorses that receive short-distance training, which places more emphasis on the component of strength, it is the relative wall thickness (RWT) that shows an increase. This is in contrast to thoroughbreds trained to run long distances. For these horses, endurance is most important and hence their relative wall thickness (RWT) stays the same, just as it does for standardbred trotters.[15]

Besides the abovementioned cardiovascular adaptations resulting from training, a relation has been found in both standardbred trotters and thoroughbreds between training and more frequent prevalence of mitral regurgitations.[4,17] An increase in mitral regurgitation is not associated with lower performance in trotters.[4] Furthermore, a relationship has been found between enhanced race performance in standardbred trotters and thoroughbreds and an increase in left ventricular internal diameter (LIVD). [3,16]

As noted before, research regarding training and cardiovascular adaptations has been conducted almost exclusively on standardbred trotters and thoroughbreds. One study carried out comparable research on dressage and jumping warmblood horses. This study described an increase in mean wall thickness (MWT) in dressage horses, whereas jumping horses exhibited an increase in left ventricular internal diameter (LVID).[13]

Regrettably, little other research has been conducted on warmblood horses. For instance, there is no study on the relation between training and an increase in echocardiographic regurgitations and/or clinically audible heart murmurs in Dutch warmblood horses.

3. Hypothesis

Training of elite Dutch warmblood horses leads to concentric hypertrophy of the heart and an increase in heart murmur and echocardiographic regurgitations.

4. Materials en methods

4.1 Horses

This study is performed with thirty Royal Dutch Sport Horses (Koninklijke Nederlandse Warmbloedpaarden, KWPN). The control group consisted of fifteen horses which were recorded in the KWPN-studbook and had a minimum age of 3 years at the time of the study. Furthermore, they had not received any kind of training yet. Of the fifteen horses in the control group, six were mares (40%), two were stallions (13%) and seven were geldings (47%). Their average age was 3.8±0.7 years, ranging from three to fourteen years old. Average height was 1.65±0.01 metres, varying from 1.59 to 1.73 metres. Average weight was 555±14 kilogrammes, with a range of 484 to 719 kilogrammes.

The dressage group consisted of horses registered in the KWPN studbook and had a minimum age of three years at the time of the study. These horses competed in dressage competitions at Z2, ZZ, Prix Saint Georges, Intermediate or Grand Prix level. Of the fifteen horses in the dressage group, two were mares (13%), and thirteen were geldings (87%). Their average age was 10.3±0.7 years, ranging from seven to eighteen years old. This group's average height was 1.72±0.01 metres, ranging from 1.68 to 1.83 metres. Their average weight was 605±11 kilogrammes, varying from 553 to 727 kilogrammes.

The horses in the dressage group were put into categories according to their level of competition at the time of the study. Of the fifteen horses studied, one horse was at Z2 level (6.7%), four at ZZ level (26.7%), five at Prix Saint Georges level (33.3%), two at Intermediate level (13.3%) and three at Grand Prix level (20%). In order to avoid making these categories too small they were merged, which resulted in two new combined categories. Group 1 consisted of Z2 and ZZ level horses (n=5). Group 2 consisted of Prix Saint Georges, Intermediate and Grand Prix level horses (n=10).

4.2 Ultrasound scanner

The echocardiographic examination is performed with a 1,5MHz phased array sector transducer [Esaote MyLabFive].

4.3 Clinical examination

The control and dressage group horses were clinically and echocardiographically evaluated at their home environment. The clinical assessment, of which the primary goal was the evaluation of the horses' cardiovascular system, was carried out by Dr. Inge Wijnberg, specialist at the European College of Equine Internal Medicine (ECEIM), and the author. The clinical examination was performed as described in 'Het klinisch onderzoek van paard en landbouwhuisdieren' by R. Kuiper and R.A. van Nieuwstadt [7] (see 4.2.1. clinical examination).

For all horses, the name, owner, sex, date of birth and date of assessment were first recorded. Then, all horses were assigned a code to allow for the anonymous processing of their data. The data obtained from the examinations were filled in standardized electronic forms. Height was measured and weight was determined using a Horse Weight Tape [VIRBAC]. After that, the horses' cardiovascular system was assessed in terms of the arterial system, capillary system, venous system and heart measurements. For the arterial system, the facial artery was rated on pulse strength, rhythm, equality and frequency. The capillary system was assessed on the basis of oral mucosa colour and conjunctivae colour. Capillary Refill Time (CRT) was measured using the oral mucosa, and peripheral body temperature was measured at the ears and legs. Turgor was measured using a fold of skin on the neck. For assessment of the venous system, venous tension of the jugular vein was measured. Venous pulse was measured at the thoracic inlet of the jugular vein. The horses were also checked for telangiectasia and edema. For the heart, auscaltation was carried out using a stethoscope [LITHMANN]. Heart sounds were rated on regularity and intensity and were also checked for murmur. If one or more instances of murmur were found, murmur intensity was determined using Table 1. The timing, location, point of maximum intensity and nature of the murmur was also determined. Systolic murmurs with a punctum maximum on the atrioventricular valves or diastolic murmurs with a punctum maximum on one of the semiluminar valves were defined as valvular murmurs of the corresponding valve. Other murmurs were defined as flow murmurs, e.g. systolic with punctum maximum over the aorta.

Table 1: Classification of heart murmurs

Grade	Characteristics
0	None audible heart murmur
1	Soft murmur, difficult to hear
2	Easy audible murmur, restricted to projection place of one valve
3	Easy audible over more than one projection place
4	Easy audible, with fremitus
5	Audible without stethoscope, with fremitus.

4.4 Echocardiographic examination

Stefanie Veraa, ECVDI Specialist Veterinary Diagnostic Imaging, performed the echocardiographic examination at the same place and not more than one day apart from the clinical examination. None of the horses had to been clipped or sedated. All measurements were made while the horse had a rest heart frequency. B-Mode, M-Mode and Color flow Doppler were performed using a 1,5MHz phased array sector transducer [Esaote MyLabFive]. The parameters measured in B-mode are presented in table 2. The parameters measured in M-mode are presented in table 3. All measurements were performed in triplicate. Table 4 presents parameters that are calculated with the mean measurements of the M-mode. A base-apex ECG lead was used for timing.

Table 2: echocardiographic measurements in the two-dimensional B-mode

Parameter	Abbreviation
Left Atrium Diameter (systole)	LADs
Pulmonary Artery Diameter	PAD
Aorta Diameter	AOD

Table 3: echocardiographic measurements in the one-dimensional M-mode

Parameter	Abbreviation
Right Ventricle Diameter (diastole)	RVDd
Interventricülair Septum (diastole)	IVSd
Left Ventriculair Diameter (diastole)	LVDd
Left Ventriculair Posterior Wall (diastole)	LVPWd
Interventriculair Septum (systole)	IVSs
Left Ventriculair Diameter (systole)	LVDs
Left Ventriculair Posterior Wall (systole)	LVPWs
E-point to septal separation	EPSS

Table 4: calculated echocardiographic parameters

Parameter	Abbreviation	Formula
Left Ventriculair Outside Diameter (diastole)	LVODd	LVODd = LVDd + IVSd + LVPWd
Left Ventriculair Mass	LVmass	$LVmass = 1.04 \times ([LVDd + LVPWd + IVSd]^3 - LVDd^3) - 13.6$
Mean Wall Thickness	MWT	MWT = (LVPWd + IVSd)/2 [4]

Colour Flow Doppler was used to determine the severity of valvular regurgitations. Categories were defined on basis of the distance the regurgitate jet was protruding away from the valve, as presented in table 5.

Table 5: definition of the regurgitation classification [11,20]

Grade	Definition	Length of jet
0	None	the jet occupied a small area behind the valve
1	Mild	the jet occupied less than 1/3 of the cardiac chamber
2	Moderate	the jet occupied between 1/3 and 2/3 of the cardiac chamber
3	Severe	the jet occupied more than 2/3 of the cardiac chamber

4.5 Registration of training status of competition horses

The degree of training experience and competition was evaluated. For this evaluation, a questionnaire was completed by the rider or trainer of each horse in the dressage group. First they were asked a number of general questions about their horse such as current competitive level, number of years of training, number of years with the current owner, number of years of active competition, number of years of Z level training, number of years of ZZ level training, number of years of Prix Saint Georges level training, number of years of Intermediate level training and number of years of Grand Prix level training.

Next, they were asked a number of questions about where the horses lived and whether they were normally let outside. If horses were let outside, follow-up questions inquired about the amount of hours a day spent outside and the type of soil on which the horses were kept. The questionnaire also asked whether horses spent time in the horse walker or not. Regarding the horse walker, the riders/trainers were asked how often the horses went into the horse walker, how much time they spent each time in the horse walker, whether they walked, trotted or galloped in the horse walker and what kind of soil was used in the horse walker.

Other questions served to gain insight in the horses' training experience. The rider was asked to provide an overview of an average intensive week of training, without competition. They were asked whether their horse received lunge training. If yes, follow-up questions asked how often the horse was lunged, for how long they were lunged each time and how much walking, trotting and galloping took place during the lunging. The rider was also asked whether they tethered the horse during lunging and on what type of soil the lunging was done. Next they were asked how often the horse was trained while saddled. A distinction was made between dressage training, endurance training, water training and outside riding. In the case of dressage training, riders were asked how many times per week dressage training took place. Here, too, there were questions about the duration of each training session, the soil on which the horse was trained, how long horses spent time in each gait, the total duration of the sequence of gaits in which the horse was trained and the duration of lateral movement and combined gait exercises. In the case of endurance training, they were asked about the number of sessions per week, the duration of each session and the soil on which the horse was trained. There were also questions about any water training the horse might have had, asking the rider about the number of water training sessions per week, the type of water training and the water's depth. The rider was also asked whether outside rides were part of the training. Finally, they were asked to rate their horse on current training intensity and fitness on a scale from 1 to 5. A sample training evaluation questionnaire can be found in Appendix 1.

Beside classification according to competition level, a second division was made according to the level of training the horses received. On the basis of the questionnaire evaluations, training intensity was given three separate categories, these being light (group 1), moderate (group 2) and heavy (group 3). The horses in group 1 were trained a maximum of five times per week. These horses were not yet tasked with performing passage or piaffe movements during dressage training. Furthermore, they were not given endurance or water training. The horses on group 2 were trained for a minimum of five times per week. During dressage training, they were asked to perform passage and piaffe exercises for a maximum of ten minutes per training session. Like those in group 1, these horses did not receive endurance or water training. The horses in group 3 also trained for a minimum of five times per week. These horses performed passage and piaffe movements for a minimum of ten minutes per training session. They also received endurance and/or water training. Of the fifteen horses in the dressage group, three received light training (group 1, 20%), eight received moderate training (group 2, 53%) and four received heavy training (group 3, 27%) at the time of the study.

4.6 Statistical analysis

Statistical analysis methods were chosen based on consultancy of the University statistician dr. J. Van de Broek. Descriptive analysis of height, weight and echocardiography findings was performed using the calculated mean. Difference in height and weight between control and dressage horses was tested using a T-test.

Descriptive analysis of valvular murmurs was performed using the frequency of severity in control and dressage horses. For the difference in the prevalence of valvular regurgitation detected with Doppler echocardiography descriptive analysis was performed.

Univariate General linear model of SPSS v.20 with body weight as covariate was used for analysing the difference in echocardiographic measurements between group, competition level and training intensity. A p-value of less than 0.05 was considered to be significant. Normality of the variables was check by the Q-Q plot of the residues. Post-hoc Bonferroni correction was used to determine which group caused the difference.

5. Results

None of the horses showed pathologic abnormalities during the clinical examination and no morphological abnormalities were found during the echocardiographic examination.

5.1 Height and weight

As presented in table 6 the total group of dressage horses is significantly larger (P=0.000) and heavier (P=0.019) than the control group.

Table 6: height and weight of control and dressage horses

		Mean	Std. deviation	Minimum	Maximum	P-value
Height	Control	1,65	,035	1,59	1,73	0.000*
	Dressage	1,72	,041	1,68	1,83	
Weight	Control	555	55,5	484	719	0.019*
	Dressage	605	44,7	553	727	
* =P<0.05						

5.2 Echocardiographic examination

As presented in table 7 the right ventricle diameter in diastole (RVDd) (P=0.023), the interventriculair septum in diastole (IVSd) (P=0.004), the pulmonary artery diameter (PAD) (P=0.011), the left ventriculair mass (LVmass) (P=0.038) and the mean wall thickness (MWT) (P=0.006) were significant larger in the total dressage group than in the control group.

Table 7: echocardiographic measurements and P- value obtained with general linear model with bodyweight as covariate between control and dressage horses.

Parameter	Mean		P-value
	Control	Dressage	
RVDd	25.060	28.613	0.023*
IVSd	29.424	32.858	0.004*
LVDd	114.786	116.830	0.585
LVPWd	31.705	34.000	0.088
IVSs	48.499	51.021	0.126
LVDs	67.128	68.097	0.749
LVPWs	45.771	46.678	0.579
EPSS	8.878	8.773	0.919
LADs	122.42	125.00	0.481
PAD	52.921	57.415	0.011*
AOD	71.418	75.337	0.148
LVODd	175.915	183.687	0.067
LVmass	4152.985	4825.808	0.038*
MWT	30.564	33.429	0.006*
* =P<0.05			

5.3 Echocardiographic examination classified to competition level

As presented in table 8 there was a significant difference in interventriculair septum in diastole (IVSd) (P=0.010), the left ventriculair posterior wall in diastole (LVPWd) (P=0.042), the E-point tot septal separation (EPSS) (P=0.008), the pulmonary artery diameter (PAD) (P=0.033) and the mean wall thickness (MWT) (P=0.005) between the different competition level groups.

The post hoc Bonferroni revealed that the IVSd (P=0.010), LVPWd (P=0.042) and MWT (P=0.003) were significant larger in group 2 than group 0. Using post hoc Bonferroni, EPSS (P=0.006) of group 1 is significant larger than group 2 too. It was not possible to trace with post hoc Bonferonni which specific level group caused the difference in PAD, probably because of the small sample size. Although table 8 showed that there is no significant difference in LVmass between the different competition level groups, post hoc Bonferroni revealed that LVmass of group 2 is significant larger than group 0 (p=0.047)

Table 8: echocardiographic measurements and P- value obtained with general lineair model with bodyweight as covariate between control and competition level groups.

Parameter	**Mean**			**P-value**
	Group 0	Group 1	Group 2	
RVDd	25.030	28.219	28.856	0.076
IVSd	29.354	31.946	33.420§	0.010*
LVDd	114.784	116.809	116.842	0.864
LVPWd	31.547	31.947	35.263§	0.042*
IVSs	48.523	51.330	50.831	0.310
LVDs	67.038	66.924	68.818	0.860
LVPWs	45.814	47.235	46.335	0.795
EPSS	9.073	11.308§	7.213	0.008*
LADs	122.41	124.94	125.03	0.748
PAD	52.997	58.398	56.809	0.033*
AOD	71.481	76.152	74.836	0.337
LVODd	175.685	180.702	185.525	0.136
LVmass	4126.138	4477.155	5040.405§	0.051
MWT	30.450	31.947	34.341§	0.005*

Group 0: control; Group 1: Z en ZZ; Group 2; Prix Saint Georges, Intermediair en Grand Prix
* =P<0.05
§=Significant different (P<0.05) from other groups with post hoc Bonferroni correction

5.4 Echocardiographic examination classified to level of training

As presented in table 9 there was a significant difference in the interventriculair septum in diastole (IVSd) (P=0.007), the left ventriculair posterior wall in diastole (LVPWd) (P=0.023), the E-point tot septal separation (EPSS) (P=0.031), the left ventriculair mass (LVmass) (P=0.019) and the mean wall thickness (MWT) (P=0.002) between the different training level groups.

The post hoc Bonferroni revealed that the IVSd (P=0.008), LVmass (P=0.012) and the MWT (P=0.002) were significant larger in group 3 than group 0. The MWT of group 3 is also significant larger than group 1 (P=0.036) and the MWT of group 2 is significant larger than group 0 (P=0.019). EPSS of group 1 is significant larger than group 3 (P=0.021). It was not possible to trace with post hoc Bonferonni which specific level group caused the difference in LVPWd, probably because of the small sample size.

Table 9: echocardiographic measurements and P- value obtained with general lineair model with bodyweight as covariate between control and training intensity groups

Parameter	**Mean**				**P-value**
	Group 0	Group 1	Group 2	Group 3	
RVDd	24.849	25.660	29.303	30.239	0.054
IVSd	29.238	31.422	32.522	35.305§	0.007*
LVDd	114.710	118.945	114.517	120.151	0.687
LVPWd	31.408	30.271	34.621	36.666	0.023*
IVSs	48.360	50.804	50.098	53.524	0.241
LVDs	67.053	67.821	67.718	69.341	0.974
LVPWs	45.625	47.190	45.092	50.013	0.217
EPSS	9.146	11.852§	8.446	6.114	0.031*
LADs	122.37	128.24	122.02	128.68	0.481
PAD	53.051	59.999	56.372	57.075	0.050
AOD	71.362	75.661	74.627	76.724	0.517
LVODd	175.357	180.639	181.660	192.122	0.096
LVmass	4091.39	4390.53	4681.85	5671.169§	0.019*
MWT	30.323	30.847	33.572§	35.985§	0.002*

Group 0: control; Group 1: light intensity; Group 2: moderate intensity; Group 3: heavy intensity
* =P<0.05
§=Significant different (P<0.05) from other groups with post hoc Bonferroni correction

5.5 Valvular murmurs

The prevalence and severity of valvular murmurs found with clinical examination in the control group and the dressage group are presented in table 10 and graph 1. In none of the horses a diastolic murmur of the pulmonary valve was detected. None of the control horses had a diastolic aorta murmur while one dressage horse (7%) had a 3/5 diastolic murmur of the aorta valve. One (7%) of the control horses had a 1/5 systolic murmur and one (7%) had a 2/5 systolic murmur of the mitral valve. One (7%) dressage horses had a 1/5 systolic murmur, one (7%) had a 2/5 systolic murmur and another three (20%) had a 3/5 systolic murmur of the mitral valve. This accounts for a prevalence of mitral valve murmurs of 13% in the control group and 33% in the dressage group.

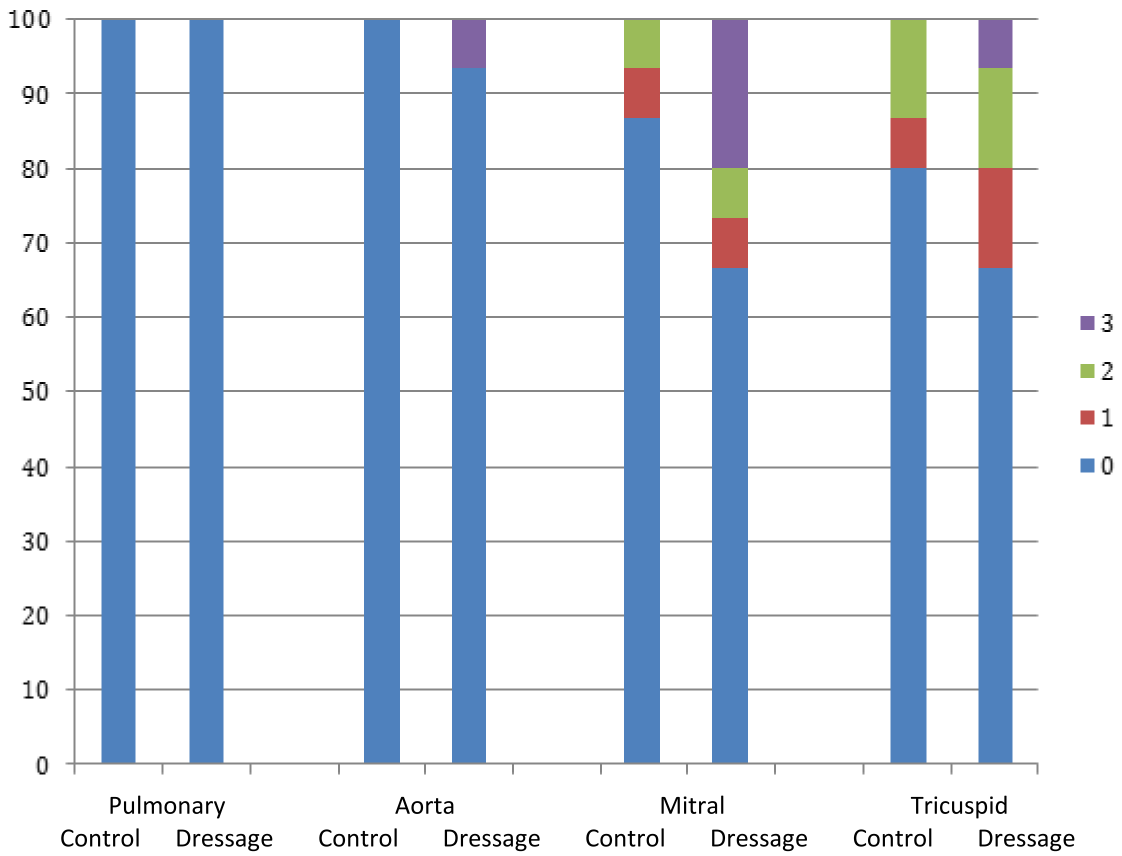
The prevalence of systolic tricuspid murmurs was 20% in the control group since one horse (7%) had a 1/5 murmur and two horses (13%) had a 2/5 murmur of the tricuspid valve. In the dressage group, two horses (13%) had a 1/5, two horses (13%) had a 2/5 systolic murmur and another one (7%) had a 3/5 systolic murmur of the tricuspid valve accounting for a prevalence of 33%.

The prevalence of flow murmurs, e.g. systolic murmur with punctum maximum over the aorta or diastolic murmur with punctum maximum over the tricuspid valve, was 27% in the dressage group since three horses (20%) had a flow murmur of the aorta valve and one horse (7%) had a flow murmur of the tricuspid valve

Table 10: Prevalence and intensity of valvular murmurs found with clinical examination in the control group and the dressage group

		Control		**Dressage**	
Valve	Intensity	Number	Percentage	Number	Percent age
Pulmonary	0	15	100%	15	100%
Aorta	0	15	100%	14	93%
	3	0	0%	1	7%
Mitral	0	13	87%	10	67%
	1	1	7%	1	7%
	2	1	7%	1	7%
	3	0	0%	3	20%
Tricuspid	0	12	80%	10	67%
	1	1	7%	2	13%
	2	2	13%	2	13%
	3	0	0%	1	7%

Graph 1: Intensity of the valvular murmurs



5.6 Valvular regurgitations
The prevalence and severity of regurgitations found with Color Flow Doppler (CFD) in the control group and the dressage group are presented in table 11 and graph 2. A mild valvular regurgitation of the pulmonary valve was detected in one horse (7%) out of the control group. In the dressage group one horse (7%) had a mild regurgitation of the pulmonary valve too.

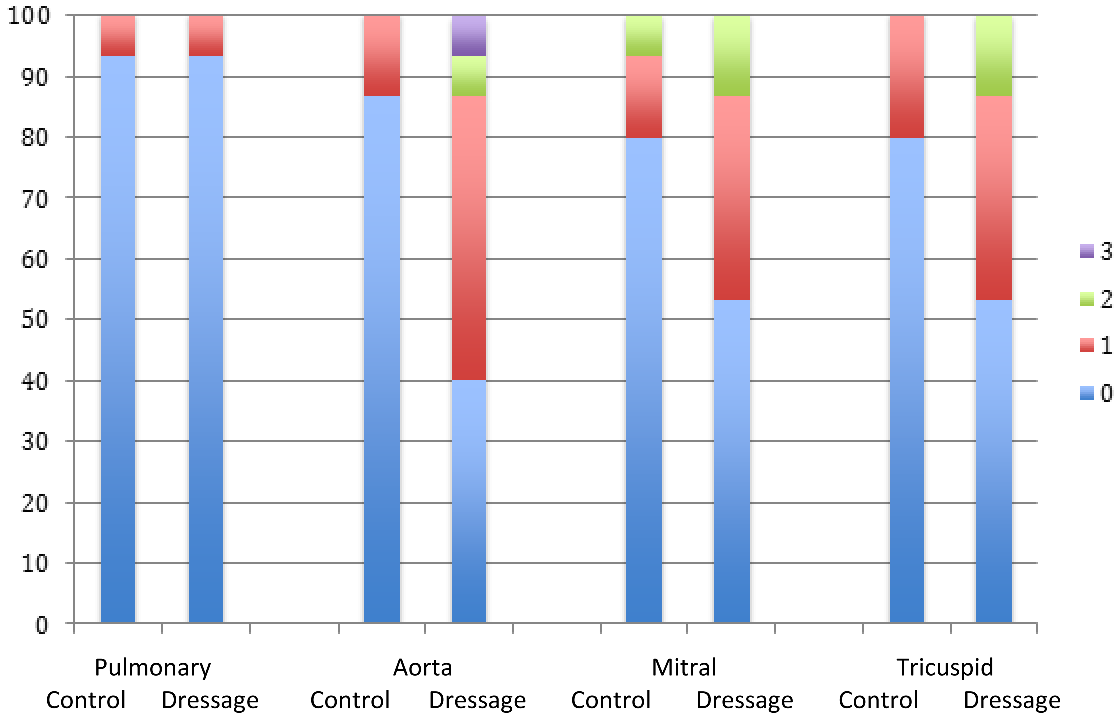
Two (13%) of the control horses had a mild regurgitation of the aorta valve while seven (47%) dressage horses had a mild, one (7%) had a moderate and another one (7%) had a severe regurgitation of the aorta valve. This accounts for a prevalence of aorta valve regurgitation of 13% in the control group and 60% in the dressage group.

Regurgitation of the mitral valve was shown in 20% of the control group of which two (13%) were mild and one was moderate (7%) in intensity. 47% of the horses in the dressage group had mitral valve regurgitation of which five horses (33%) had a mild and two horses (13%) had a moderate intensity regurgitation. Three control horses (20%) had a mild regurgitation of the tricuspid valve. A regurgitation of the tricuspid valve was detected in 47% of the dressage horses of which five (33%) were mild and two (13%) were moderate intensity.

Table 11: prevalence and severity of regurgitations found with Color Flow Doppler (CFD) in the control group and the dressage group

		Control		**Dressage**	
Valve	Severity	Number	Percentage	Number	Percentage
Pulmonary	0	14	93%	14	93%
	1	1	7%	1	7%
Aorta	0	13	87%	6	40%
	1	2	13%	7	47%
	2	0	0%	1	7%
	3	0	0%	1	7%
Mitral	0	12	80%	8	53%
	1	2	13%	5	33%
	2	1	7%	2	13%
Tricuspid	0	12	80%	8	53%
	1	3	20%	5	33%
	2	0	0%	2	13%

Graph 2: Intensity of the valvular regurgitation



6. Discussion

In this study 15 non-trained horses and 15 dressage horses that competed at Z-level and higher underwent a physical and echocardiographic examination. It showed that healthy and fit dressage horses had a higher prevalence of valvular murmurs of the aorta, mitral and tricuspid valve than horses that are untrained. Also the prevalence of valvular regurgitations of the aorta, mitral and tricuspid valve detected with Doppler echocardiography was higher in the dressage group than in the control group. The echocardiographic parameters RVDd, IVSd, PAD, LVmass and MWT were significantly higher in dressage than control horses. Competition level groups differed in IVSd, LVPWd, EPSS, PAD, LVmass and MWT while training level groups differed in IVSd, LVPWd, EPSS, LVmass and MWT.

The control group horses had a minimum age of three years to exclude an effect of normal physical growth on the echocardiographic parameters[1]. We assumed that the limited activity of the control horses would not cause heart adaptations. This study used General Linear Model with bodyweight as covariate for the statistical analysis of the echocardiographic measurements. General Linear Model can correct for the influence of body weight. Many authors suggest that echocardiographic parameters were influenced by body weight[1,2,8,12,16]. Others disagree with this statement[9]. We wanted to include weight as covariate because of the wide range in weight in our horses. Gender was not considered in statistical analysis, since previous studies show that heart dimensions are not influenced by gender[1,19].

Since no published data is available on prevalence's of valvular murmurs in untrained adult warmblood horses we could only compare our control group results with literature on untrained but younger thoroughbreds. Our control group had a prevalence of valvular murmurs of the mitral and tricuspid valve (13% and 20%, respectively) that was comparable with the results obtained in 2-year-old thoroughbreds before training (7% and 20%, respectively)[17]. Remarkably, a comparable study of the same author revealed higher prevalence's of mitral and tricuspid valve murmur (24% and 44%, respectively) in 2-year-old thoroughbreds that were not trained yet[17].

It is impossible to compare the prevalence of aorta, mitral and tricuspid valve murmurs (7%, 33% and 33%, respectively) in our group of dressage horses with other dressage horses or warmblood horses in general due to a lack of research. It is possible to compare the prevalence of these murmurs in dressage horses with thoroughbreds (0%, 20% and 20%, respectively)[16] or national hunt horses (7%, 23% and 44%, respectively)[17]. However, the method and intensity of training between dressage horses, thoroughbreds and national hunt horses differs very much so this comparison has little value.

Doppler echocardiography of the control horses revealed a prevalence of the pulmonary, aorta, mitral and tricuspid valvular regurgitation (7%, 13%, 20% and 20%, respectively) that was higher than published in untrained, 2-year-old standardbred trotters (0%, 0%, 3%, 8%)[4] and untrained, 2-year-old thoroughbreds (0%, 0%, 7,3%, 12,7%, respectively)[18]. However, other reports mentioned higher prevalence's of aorta, mitral and tricuspid valve regurgitation (38%, 29%, 75%, respectively) in 2-year-old thoroughbreds[17].

Like the murmurs, it is impossible to compare valvular regurgitation of the pulmonary, aorta, mitral and tricuspid valve in our group of dressage horses (7%, 60%, 47% and 47%, respectively) with vavular regurgitation in dressage horses or warmblood horses in general due to a lack of research. We can compare these valvular regurgitations with trained, 5-year-old standardbred trotters (42,5%, 60%, 37,5% and 87,5%, respectively)[4]. We can conclude that there is an increase in murmurs and echocardiographic regurgitations as a result of training in our group of dressage horses. This is similar to research performed with thoroughbreds and standardbred trotters in the past[4,10,18].

The dressage horses had a significant bigger RVDd than the control horses. Because of the U-shape of the right ventricle that envelops the left ventricle, it is challenging to standardise the measurements of the RVDd. However, the day-to-day repeatability of the RVD measurement is acceptable.[5] Our results are not in accordance with a study in warmblood dressage and show jumping horses by Stadler et al.[13] He found no significant difference between the RVDd in warmblood dressage, jumping and control horses. It is difficult to compare the groups of dressage horses between the study of Stadler et al. and our study because the level of training in the study of Stadler et al. is unclear.

The IVSd measured in our group of dressage horses was significant larger than in our control group. This was in accordance with the study of Stadler et al.[13] They found a significant thickening of the IVS in dressage horses compared with show jumping horses and untrained horses. Our finding that dressage horses had bigger IVSd than the control horses was in accordance to studies in thoroughbreds.[15,16] The IVSd in both the groups with the highest level of training and the highest level of competition are significant larger than the control group. This is in accordance with what we expected due to resistance training being a component of the training. The LVPWd of the group with the highest level of competition is significant larger than the control horses. This is again in accordance with the study of Stadler et al. in where they found an increase in LVWP as a result of training in warmblood dressage horses.[13] The larger MWT in dressage horses compared to control horses in our study was in accordance to the difference between trained and untrained thoroughbreds[15,16], standardbred trotters[4] and warmblood dressage horses[13].

Although more research is necessary, especially with bigger groups of elite dressage warmblood horses, these results are in accordance with our hypothesis that training of elite Dutch warmblood horses leads to concentric hypertrophy of the heart and an increase in heart murmur and echocardiographic regurgitations.

7. Referenties

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