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EQUINE NECK MOVEMENT: COMPARING SEGMENTAL KINEMATICS AND PRECISION RECALL OF TRAJECTORIES AND VELOCITIES

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SUMMARY
The retrieval of 3D motion capture data is a well-established method in animation to find similar motion sequences in large databases. The aim of this study was to compare similarities of motion patterns of the equine head-neck-withers segment in five horses walking and trotting on a treadmill. Trajectories and velocities of skin markers (crista facialis, C1, C3, C6, withers, four hooves) were analyzed. Motion pattern similarities were higher at walk than at trot in all segments. At walk maximum precision (% retrieved instances that are relevant) was 66 %, and at trot maximum recall (% relevant instances that are retrieved) was 12%, both at C3-C6. Different to the larger kinematic variations of head and neck movement at walk, this approach of identifying the movement pattern as a whole showed a more consistent pattern of segmental movement at walk than at trot, illustrating the similarities in vertebral joint movements.

INTRODUCTION
Retrieval of 3D motion capture data is a well-established method to identify similarity of motion sequences in large databases [1]. The aim of this study was to compare similarities of motion patterns of the equine head-neck-withers segment.

METHODS
In vivo measurements were taken in five horses without clinical signs of neck and back pain. Clinical examination (palpation of the vertebrae and the musculature, as well as evaluation of passive and active neck movement) revealed no abnormal findings. Horses were without history of neck or back trauma or surgeries.

Thirteen reflective skin markers were attached to each horse using adhesive tape. Six markers were placed on left and right side on the first, third and sixth vertebrae Additional markers were placed on the head (forehead, left and right crista facialis), on the highest point of the withers. The kinematic data were collected in a standard right-handed Cartesian coordinate system using ten digital infrared cameras (Eagle Digital Real Time System, Motion Analysis Corp., Santa Rosa, California, USA) recording at 120 Hz. Data collection continued until 3 trials (each 10 seconds) in both gaits had been recorded. The 3-dimensional coordinates of each marker during the time course of each experiment were calculated from the data by Cortex (3.6.1., Motion Analysis Corp., Santa Rosa, California, USA.) software. The kinematic data has then been smoothed by use of a Butterworth low-pass filtered (cut-off frequency, 10 Hz).

In five horses walking and trotting on a treadmill, trajectories and velocities of thirteen skin markers (bilateral crista facialis, C1, C3, C6) were analyzed in relation to the withers. The accuracy of detection of motion similarities was evaluated employing precision (% retrieved instances that are relevant) versus recall (% relevant instances that are retrieved) graphs. For retrieval, markers were annotated for all motion sequences in order to calculate precision and recall values, followed by comparisons of all trials of all horses. Based on the Euclidean distance of all markers, the nearest neighbors were connected with a lazy neighborhood graph to retrieve motion segments [2].

RESULTS AND DISCUSSION
Segmental trajectory results of the individuals showed a larger interindividual variation at walk than at trot, with a larger intraindividual variation at walk in one horse with no difference in the other horses (Table 1). Segmental velocity results of the individuals showed a larger interindividual and intraindividual variation at trot than at walk.

At maximum precision, recall was highest (72 % for trajectory velocity at walk and 13 % at trot). Among the segments, C3 and C6 had the highest recall at walk (66 %) and at trot (12 %). This approach identified more motion similarities of segmental movement over all individuals at walk, than at trot. For trot interindividual similarities were smaller and intraindividually more specific than at walk.

CONCLUSIONS

Previously variations of head and neck movements were found to be larger at walk than at trot [3], and this was also found for the segmental trajectories in this study. Despite this, walk patterns independent of head position are more strongly similar between subjects than trot patterns.

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Table 1: Mean and standard deviation of marker trajectories, marker velocities; precision/recall and recall/precision values at walk and at trot (CF- crista facialis, C1- first cervical vertebrae, C3- third cervical vertebrae, C6- sixth cervical vertebrae, W- withers)

		Walk			Trot		
		X	**Y**	**Z**	**X**	**Y**	**Z**
Marker trajectories [mm]	**CF**	1484 ± 174	181 ± 146	1241 ± 131	1434 ± 194	136 ± 108	1467 ± 90
	C1	1265 ± 177	174 ± 160	1481 ± 117	1179 ± 214	138 ± 113	1651 ± 69
	C3	1078 ± 180	178 ± 164	1383 ± 67	1044 ± 200	144 ± 123	1491 ± 38
	C6	867 ± 167	132 ± 180	1299 ± 35	882 ± 189	145 ± 136	1333 ± 30
	W	484 ± 156	161 ± 105	1520 ± 75	527 ± 171	133 ± 15	1494 ± 75
Marker velocities [mm/s]	**CF**	76 ± 17	103 ± 16	225 ± 101	171 ± 54	153 ± 69	311 ± 21
	C1	122 ± 52	62 ± 8	155 ± 39	183 ± 58	95 ± 30	315 ± 11
	C3	80 ± 16	59 ± 5	97 ± 13	129 ± 11	85 ± 29	292 ± 37
	C6	95 ± 17	59 ± 1	88 ± 21	131 ± 20	97 ± 19	261 ± 65
	W	70 ± 5	79 ± 7	63 ± 18	189 ± 17	141 ± 25	261 ± 45

		Precision/Recall			Recall/Precision		Precision/Recall			Recall/Precision	
Segments	**CF-C1**	1	0.61		1	0.889	1	0.06		0.414	0.371
	C1-C3	1	0.65		1	0.909	1	0.11		0.387	0.366
	C3-C6	1	0.66		1	0.932	1	0.12		0.368	0.369
	C6-W	1	0.52		1	0.849	1	0.11		0.359	0.332
	Velocity	1	0.72		1	0.941	1	0.13		0.384	0.387