Range of motion and power output in elite able-bodied athletes and elite para-athletes during kayak paddling

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Para-kayak

- Double-blade paddle
- Complex three-dimensional (3D) movement
- Para-kayak new Paralympic sport, accepted for the Paralympic Games in Rio 2016
- New evidence-based classification system

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Para-kayak classification system

KL1

KL2

KL3

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Purposes

- Define 3D power output, range of movement (RoM), maximal and minimal peak angles in elite able-bodied athletes and elite para-athletes

- Examine the differences in 3D RoM, maximal and minimal peak angles between the able-bodied athletes and the three para-athlete classes

- Correlate individual joint angles with power output for both groups

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Method - participants

- 10 elite able-bodied athletes from Sweden
  (4 females and 6 males;
  22 ± 3.5 years, 78.3 ± 10.2 kg, 1.79 ± 0.06 m)

- 41 para-kayak athletes (13 females and 28 males)
  from 12 different countries from four continents
  (35 ± 9.0 years, 70.6 ± 12.5 kg, 1.74 ± 0.12 m)

- KL1 n=9, KL2 n=14, KL3 n=18

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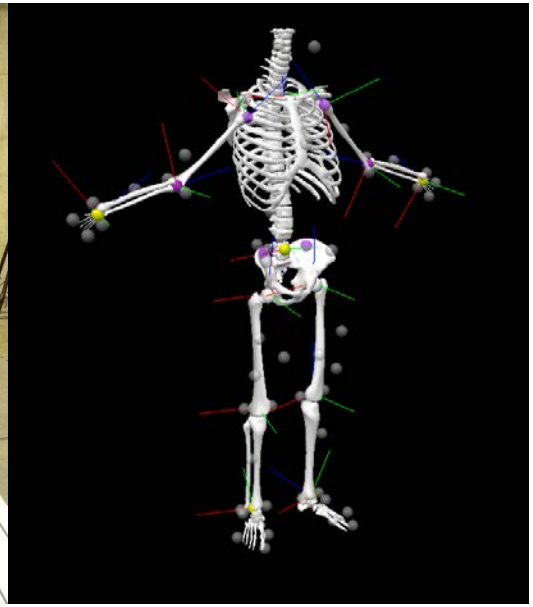
Method - 3D kinematics



- 12-camera 3D optoelectronic system (Oqus 4, Qualisys)
- 150 Hz
- 39-64 reflective markers
- Whole-body model consisting of 14 segments.

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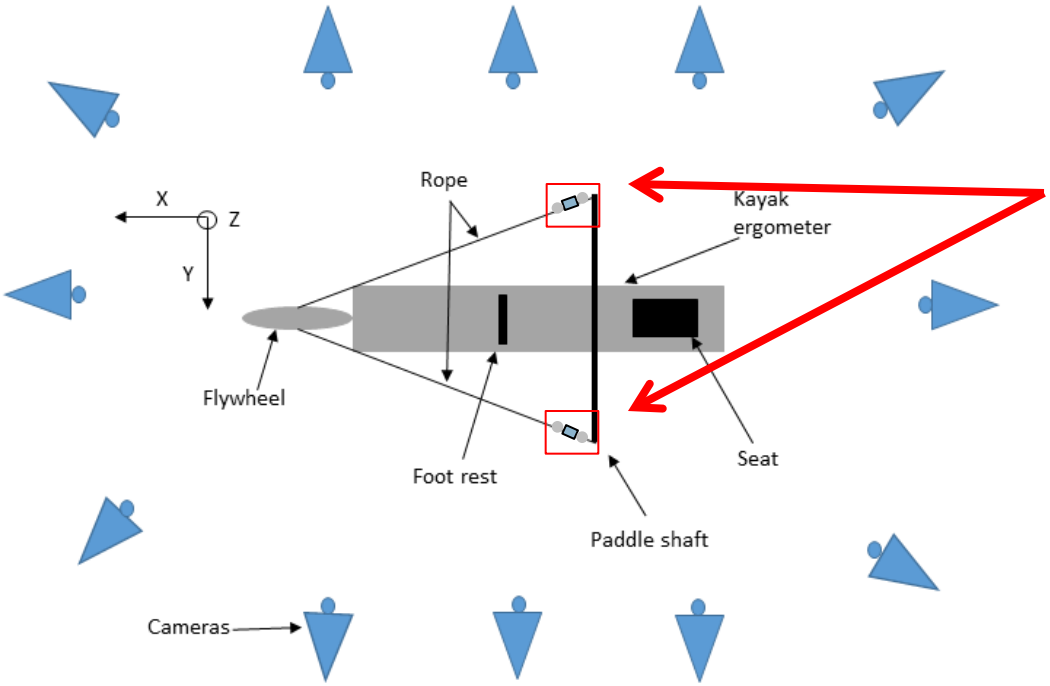
Method - kinetics



- 2 piezoelectric force transducers
- 1500 Hz
- 3D power output

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Method - test protocol on ergometer

- Warm-up

- High intensity, i.e. the highest level that the athlete could stably maintain during 20 stroke cycles.

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Method - statistical analyses

- Two-way and three-way ANOVA
- Pearson’s correlation coefficient
- All results were considered to be significant when $p \leq 0.05$.

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Results

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		KL1	KL2	KL3	Able-bodied athletes	Sign. diff
		Mean ± SD (°)	Mean ± SD (°)	Mean ± SD (°)	Mean ± SD (°)	
Shoulder	Flexion/Extension RoM	137.4 ± 10.8	134.3 ± 18.3	119.7 ± 14.8	89.4 ± 7.5	a, b, c
	Extension (maximum)	55.2 ± 7.5	35.4 ± 13.1	14.0 ± 12.8	-14.2 ± 9.1	a, b, c, d, e, f
	Abduction RoM	63.4 ± 10.4	63.4 ± 9.4	54.6 ± 14.2	40.3 ± 6.4	a, b
	Rotation RoM	105.8 ± 16.5	104.6 ± 14.0	99.5 ± 19.2	70.0 ± 7.1	a, b, c

Significant difference between:

a= able-bodied and KL1
b= able-bodied and KL2
c= able-bodied and KL3
d= KL1 and KL2
e= KL1 and KL3
f= KL2 and KL3

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		KL1	KL2	KL3	Able-bodied athletes	Sign. diff
		Mean ± SD (°)	Mean ± SD (°)	Mean ± SD (°)	Mean ± SD (°)	
Trunk	Flexion (maximum)	-13.5 ± 6.2	-2.9 ± 6.9	4.7 ± 7.2	5.5 ± 3.1	a, b, d, e, f
	Extension (maximum)	19.8 ± 7.0	9.8 ± 6.6	2.8 ± 7.5	0.3 ± 4.3	a, b, d, e, f
	Rotation RoM	52.5 ± 20.5	63.7 ± 12.9	71.5 ± 12.0	101.9 ± 3.1	a, b, c, e

Significant difference between:

a= able-bodied and KL1 d= KL1 and KL2

b= able-bodied and KL2 e= KL1 and KL3

c= able-bodied and KL3 f= KL2 and KL3

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		KL1	KL2	KL3	Able-bodied athletes	Sign diff.
		Mean ± SD (°)	Mean ± SD (°)	Mean ± SD (°)	Mean ± SD (°)	
Hip	Flexion RoM	8.5 ± 3.4	8.9 ± 5.4	15.5 ± 6.3	31.4 ± 4.9	a, b, c
Knee	Flexion RoM	8.8 ± 6.8	8.4 ± 8.4	22.4 ± 11.1	45.5 ± 6.7	a, b, c, f
Ankle	Flexion RoM	5.9 ± 3.9	4.5 ± 3.8	9.8 ± 5.7	29.2 ± 8.9	a, b, c
	Significant difference between: a= able-bodied and KL1 d= KL1 and KL2 b= able-bodied and KL2 e= KL1 and KL3 c= able-bodied and KL3 f= KL2 and KL3					

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	Power vs. sport specific RoM and joint angles				
		Males		Females	
		Pearson r	*p*-value	Pearson r	*p*-value
Shoulder	Flexion RoM	-0.43	0.018	-0.79	<0.001
	Abduction RoM	-0.42	0.020	-0.53	0.024
	Rotation RoM	-0.44	0.015	-0.77	<0.001
Trunk	Flexion Maximum	0.83	<0.001	0.56	0.017
	Rotation RoM	0.66	<0.001	0.83	<0.001
	Bending RoM	-0.48	0.007	-0.56	0.016
Leg	Hip Flexion RoM	0.71	<0.001	0.82	<0.001
	Knee Flexion RoM	0.69	<0.001	0.88	<0.001
	Ankle Flexion RoM	0.38	0.039	0.79	<0.001

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Discussion

- Differences in trunk rotation, hip, knee and ankle flexion RoM and trunk flexion maximum is observed between able-bodied athletes and para-athletes. These joint angles also correlates positively with power output.
- Sitting in a forward flexed trunk position and rotation the trunk may give a greater forward reach[2]
- Athletes in KL1 and KL2 compensate for their impairment by increased use of arm movement

[2] Brown et al 2011

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Conclusion

- Being able to sit in a forward flexed trunk position, rotating the trunk and moving the legs correlates with producing a higher power output.

- This study contains valuable information for coaches.

- The physical assessment in the new classification system includes tests of trunk and leg muscle function in sport specific RoM. These values were derived from the results from this research study.

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Acknowledgements

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THANK YOU

for listening

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