Optimal control for maximizing robust twisting techniques on trampoline

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Introduction

Aerial twisting techniques have gained coaches interest with the arrival of time of flight.

Simulation is a risk of injury free method allowing to find innovate twisting techniques.

Trampolinists mainly use arm abduction/adduction to generate twists, putting aside the change of abduction/adduction plane.

Objective

The purpose of this study is to examine more complex aerial arm twisting techniques allowing shoulder full motion in a backward straight somersault with a multiple-shooting algorithm to find innovative and robust twisting techniques.

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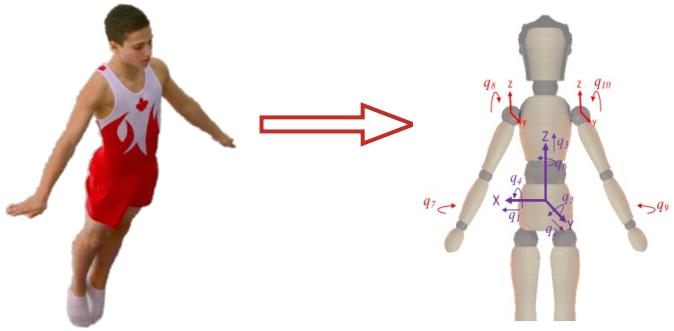
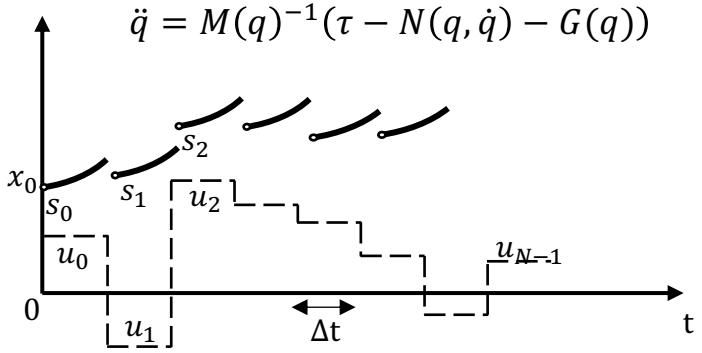
Method

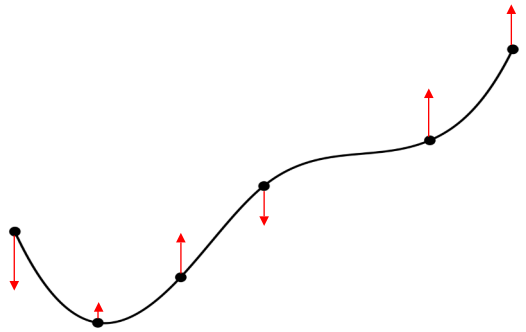


3D Model composed of 10 degrees-of-freedom (DOFs) allow to find techniques with computer simulation.

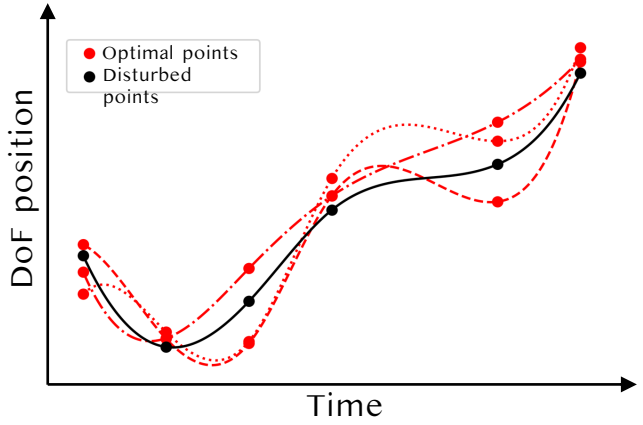
$$\ddot{q} = M(q)^{-1}(\tau - N(q,\dot{q}) - G(q))$$



Multiple-shooting algorithm is used to maximize twist rotation. A multi-start approach (n = 3720) allows to find multiple [near]-ptimal solutions.



Gaussian noise is added to DoF position nodes.



The number of twists generated by disturbed movements is then approximated by interpolating quartic splines.

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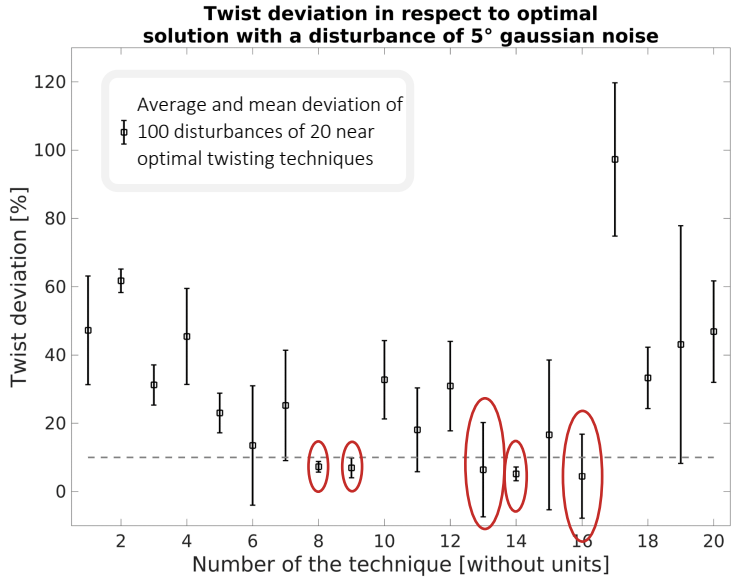
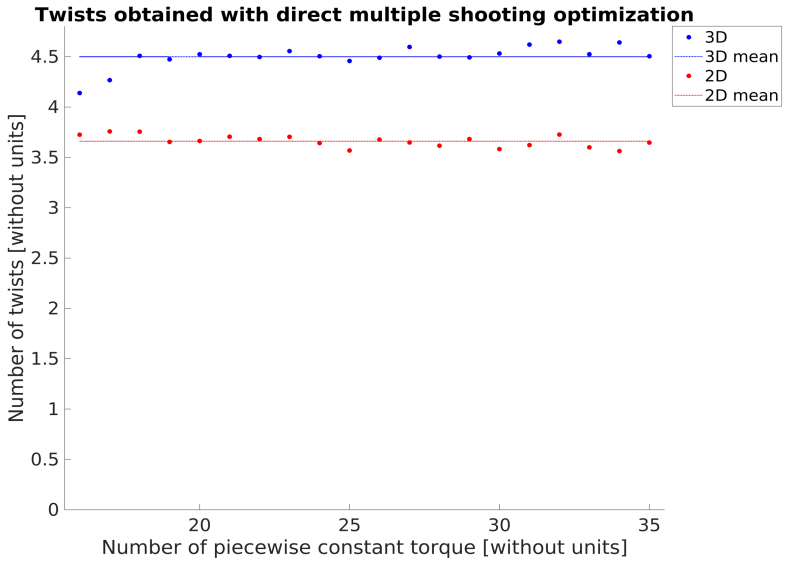
Results



There were 5 out of 20 optimal 3D techniques that were found to be robust.



The optimal 2 DoFs per arm techniques generated on average 4.5 ± 0.3 twists whereas the 1 DoF per arm techniques generated on average 3.66 ± 0.06 twists in a backward straight somersault.

Two families of similar optimal 2 DoF per arm techniques can be extracted from the optimization results

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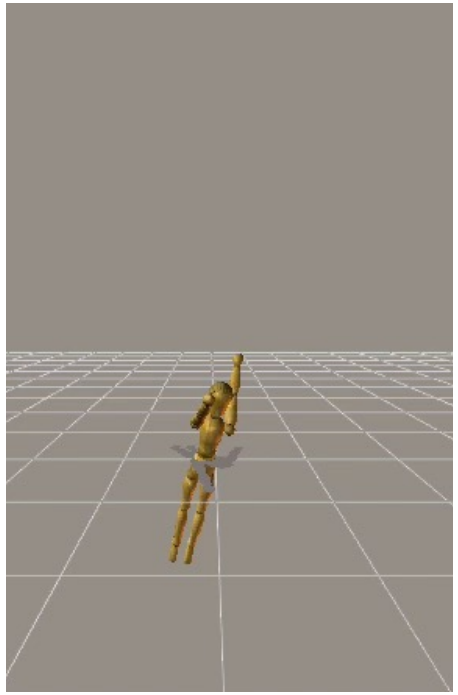
Conclusion

Arm change of plane of abduction/adduction can increase twisting performance. The gain is approximately one twist in a single backward somersault in straight position compared to abduction/adduction only.



The 2 families of 2 DoF per arm techniques found are different from the ones athletes use in competitions.

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Impact on olympic athletes

Each additional ½ twist increase the D score (difficulty) of 0.1

Aerial twisting does not imply height loss whereas contact twisting does, therefor T score (time of flight) should be improved.

Rank	Name	NOC Code	Routine	D Score	E Score	T Score	H Score	Pen.	Routine Total	Routine Rank	Total
30	PIUNOV Oleg	AZE	1st	5.600	18.400	18.325	9.250		51.575	(15)	108.840
			2nd	16.400	15.000	16.965	8.900		57.265	(38)	
31	SONN Kyrylo	GER	1st	5.800	17.600	18.500	9.200		51.100	(32)	108.810
			2nd	15.800	15.900	17.210	8.800		57.710	(32=)	
32	PROSTOROV Mykola	UKR	1st	5.200	17.900	18.105	9.700		50.905	(34)	108.615
			2nd	16.000	15.300	17.210	9.200		57.710	(32=)	
33	SWADLING Shaun	AUS	1st	5.900	17.400	17.755	9.450		50.505	(44)	108.215
			2nd	15.800	15.800	16.960	9.150		57.710	(32=)	
34	SOEHN Keegan	CAN	1st	5.400	17.800	17.780	9.500		50.480	(45)	108.090
			2nd	16.900	14.500	16.610	9.600		57.610	(36)	

The impact on E score (execution) is unknown although there is no clear rule forbidding the use of 2 DoF per arm techniques.

Aerial twisting does not cause lateral translation unlike contact twist, therefor H score (translation) can be improved.