

Humanetics Innovative Solutions, Inc.



Flex PLI

Round Robin Test Results

Instrumentation Engineering

July 21, 2012

Round Robin Testing

- ▶ Humanetics (HIS) received 2 of the 3 round robin legs (ENG Leg and SN01).
- ▶ Engineering leg had damaged ACL pot: it was decided not to repair this channel to keep leg in same condition as previously tested. Repair will be done after RR testing before shipping back.
- ▶ 3x Inverse and 3x Pendulum tests were performed on each leg using a new test fixture.
- ▶ Overview of Results:
 - HIS produces consistent and repeatable tests.
 - HIS results matched the three testing laboratories (JARI, BAST and Bertrandt).
 - The new test fixture produces better results with respect to the original fixture. Most likely as a result of the ram motion.
 - HIS results are passing within the new proposed corridors as well as passing most of the original corridors. Where HIS fails original corridors, our data is consistent with BAST and Bertrandt.

SN01 INVERSE IMPACT

	Velocity	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	MCL	PCL
Original Upper	11.30	277.00	269.00	204.00	120.00	10.50	23.00	6.0
Original Lower	10.90	237.00	223.00	176.00	98.00	8.50	18.00	4.5
Prop JARI Upper		270.96	256.18	193.21	112.17	9.8	21.81	5.68
Prop JARI Lower		230.96	210.18	165.21	90.17	7.8	16.81	4.18
Prop BAsT Upper		272.0	252.0	192.0	108.0	10.0	21.0	6
Prop BAsT Lower		230.0	210.0	166.0	93.0	8.0	17.0	4
SN01-HIS-1	10.9	242.3	224.8	173.7	100.7	8.4	19.4	5.2
SN01-HIS-2	10.9	242.9	225.7	174.3	100.6	8.8	19.8	5.1
SN01-HIS-3	10.9	249.1	231.3	178.8	102.5	8.6	20.2	5.4
SN01-JARI-1		245.8	229.9	176.7	103.0	8.6	19.5	4.9
SN01-JARI-2		254.8	238.7	183.7	103.3	8.5	19.6	4.9
SN01-JARI-3		248.0	231.1	177.3	100.1	8.6	19.1	4.7
SN01-BAsT-1		248.7	232.2	178.0	102.5	9.6	20.2	5.9
SN01-BAsT-2		246.2	230.1	175.1	98.6	9.3	20.0	4.7
SN01-BAsT-3		242.0	228.9	174.4	99.7	9.2	20.1	5.3
SN01-Bert-1		243.2	223.5	176.1	102.8	9.4	19.0	4.6
SN01-Bert-2		241.7	221.8	175.8	101.4	8.9	18.9	4.9
SN01-Bert-3		246.9	220.5	173.9	100.4	9.0	18.9	5.0

- ▶ HIS passes leg within proposed corridors. Some Tibia Gauge 3 failures with respect to original corridors.

HIS Mean	244.8	227.3	175.6	101.3	8.6	19.8	5.2
Lab Mean	246.4	228.5	176.8	101.3	9.0	19.5	5.0
StdDEV of Labs	2.9	4.4	1.9	1.4	0.3	0.4	0.3
StdDEV with HIS	3.0	4.1	2.0	1.3	0.3	0.4	0.3

SN01 PENDULUM IMPACT

	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	MCL	PCL
Upper Corridor	235.0	211.0	160.0	108.0	11.0	26.0	5.4
Lower Corridor	272.0	185.0	135.0	94.0	9.0	23.0	4.0
Prop JARI Upper	272.5	216.8	167.3	111.9	10.0	24.0	5.2
Prop JARI Lower	235.4	190.9	142.0	97.3	8.1	20.8	3.8
Prop BAST Upper	272.0	219.0	166.0	111.0	10.5	24.0	5.0
Prop BAST Lower	235.0	187.0	139.0	90.0	8.0	20.5	3.5
SN01-HIS-1	254.7	203.7	155.6	106.2	9.2	22.7	4.2
SN01-HIS-2	253.9	202.9	155.1	105.9	9.4	22.5	3.9
SN01-HIS-3	253.8	203.2	155.4	106.1	9.4	22.5	3.9
SN01-JARI-1	249.4	201.8	151.7	102.6	8.9	22.6	4.4
SN01-JARI-2	251.6	202.9	152.9	103.9	8.9	22.8	4.5
SN01-JARI-3	249.8	201.2	152.3	103.9	8.8	22.5	4.5
SN01-BAST-1	251.8	202.1	152.7	103.6	9.6	23.0	4.0
SN01-BAST-2	252.7	203.2	154.1	104.8	9.4	23.1	4.3
SN01-BAST-3	251.2	201.6	151.9	102.4	9.4	23	4.3
SN01-Bert-1	248.5	200.0	151.1	101.6	9.2	22.7	4.4
SN01-Bert-2	251.2	202.1	152.1	101.8	9.4	22.9	4.1
SN01-Bert-3	251.3	202.2	152.1	101.9	9.6	22.8	4.0

- ▶ HIS testing consistent with Europe/Japan
- ▶ HIS moments here slightly higher than other labs, but well within corridors
- ▶ Only BAST passes MCL with original corridor

HIS Mean	254.1	203.3	155.4	106.1	9.3	22.6	4.0
Lab Mean	250.8	201.9	152.3	102.9	9.2	22.8	4.3
StdDEV of Labs	1.1	0.7	0.6	1.0	0.3	0.2	0.2
STdDEV with HIS	1.9	1.0	1.6	1.7	0.3	0.2	0.2

Eng leg INVERSE IMPACT

	Velocity	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	MCL	PCL
Upper Corridor	11.30	277.00	269.00	204.00	120.00	10.50	23.00	6.0
Lower Corridor	10.90	237.00	223.00	176.00	98.00	8.50	18.00	4.5
Prop JARI Upper		270.96	256.18	193.21	112.17	9.8	21.81	5.68
Prop JARI Lower		230.96	210.18	165.21	90.17	7.8	16.81	4.18
Prop BAST Upper		272.0	252.0	192.0	108.0	10.0	21.0	6
Prop BAST Lower		233.0	216.0	167.0	93.0	8.0	17.0	4
Eleg-HIS-1	11.3	245.3	227.3	171.5	96.2	NA	19.4	5.2
Eleg-HIS-2	10.9	243.4	226.1	169.2	97.0	NA	19.6	5.3
Eleg-HIS-3	11.3	248.7	229.8	175.7	98.0	NA	19.5	5.7
Eleg-JARI-1		251.9	233.4	178.2	100.1	8.6	19.8	5.4
Eleg-JARI-2		253.5	234.4	178.4	100.2	8.8	19.4	5.3
Eleg-JARI-3		260.0	240.1	183.0	102.3	8.8	19.8	5.4
Eleg-BAST-1		247.9	232.3	176.2	98.9	8.5	19.5	5.8
Eleg-BAST-2		249.4	232.0	175.0	97.0	8.6	19.2	5.7
Eleg-BAST-3		252.8	236.8	180.4	102.4	9.1	19.2	5.2
Eleg-Bert-1		252.3	229.7	178.0	101.8	8.8	18.8	5.1
Eleg-Bert-2		250.4	227.9	174.8	99.5	9.9	18.8	5.3
Eleg-Bert-3		252.0	227.4	175.7	100.9	NA	18.6	5.2

HIS Mean		244.4	226.7	170.4	96.6	NA	19.5	5.3
Lab Mean		252.2	232.7	177.7	100.3	8.9	19.2	5.4
StdDEV of Labs		2.1	3.1	2.1	1.3	0.3	0.3	0.2
STdDEV with HIS		3.1	3.4	2.7	1.8	NA	0.3	0.2

- ▶ ACL potentiometer failed during Bertrandt testing and has not been replaced to keep leg in same condition.
- ▶ HIS results are consistent with other labs, but slightly lower.

Eng leg PENDULUM IMPACT

	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	MCL	PCL
Original Upper	272.0	211.0	160.0	108.0	11.0	26.0	5.4
Original Lower	235.0	185.0	135.0	94.0	9.0	23.0	4.0
Prop JARI Upper	272.5	216.8	167.3	111.9	10.0	24.0	5.2
Prop JARI Lower	235.4	190.9	142.0	97.3	8.1	20.8	3.8
Prop BAST Upper	272.0	219.0	166.0	111.0	10.5	24.0	5.0
Prop BAST Lower	235.0	187.0	139.0	90.0	8.0	20.5	3.5
SN01-HIS-1	253.4	202.1	152.3	101.7	NA	21.8	4.5
SN01-HIS-2	255.6	204.3	154.0	102.7	NA	22.0	4.2
SN01-HIS-3	255.9	204.9	154.7	103.2	NA	22.1	4.3
ENG1-JARI-1	258.0	205.6	155.6	105.0	9.2	22.4	4.6
ENG1-JARI-2	259.9	208.8	158.3	106.4	9.2	22.8	4.8
ENG1-JARI-3	258.7	207.6	157.5	106.1	9.4	22.4	4.4
ENG1-BAST-1	255.1	203.8	152.5	101.1	9.9	22.3	4.1
ENG1-BAST-2	257.6	206.0	153.8	101.9	9.8	22.4	4.2
ENG1-BAST-3	254.0	202.9	151.7	100.3	9.6	21.9	4.0
ENG1-Bert-1	258.3	207.3	156.2	104.7	9.5	22.1	4.2
ENG1-Bert-2	259.7	208.4	156.9	104.9	9.6	22.3	4.2
ENG1-Bert-3	259.3	208.1	156.8	104.9	9.7	22.5	4.3

- ▶ ACL potentiometer failure
- ▶ Results consistent with other labs

HIS Mean	255.0	203.8	153.7	102.5	NA	22.0	4.3
Lab Mean	257.8	206.5	155.5	103.9	9.5	22.3	4.3
StdDEV of Labs	1.5	1.7	1.9	1.9	0.2	0.2	0.2
STdDEV with HIS	1.9	1.9	1.9	1.8	NA	0.2	0.2

Discussion Inverse

- ▶ All RR Results were inside the proposed new corridors. However there is concern with the more narrow T4 corridor. Range reduction is 31%. Looking at SN04 results in GTR-3-05, T4 results reduced the most over time by up to 20 Nm in 2.3 years. Part of the reason for drop could be due to short then long rubber? Some tested values on Eng leg are only 3-4 Nm above proposed corridor. SN04 T4 channel also reduced the most after initial car testing.

Discussion Pendulum

- ▶ From test results no major concern with proposed corridors but would like to see certification performance after car testing before finalizing.

Conclusion

- ▶ Humanetics results were consistent with previous RR tests within the new proposed corridors.
- ▶ It is recommended that certification is carried out after some car testing before finalizing corridors to check conformity particularly with the T4 inverse channel

Thank You!