

Strength Differences Between Athletes After Rehabilitation of a Severe Lower Extremity Injury and Non-injured Athletes

A Study of High-Level Alpine Ski Racers

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Keywords

Alpine skiing, severe injury, return to sport, maximal and explosive strength

References

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Introduction

- ▶ Maximal strength (F_{max}) & explosive strength (P_{max}): performance-relevant strength profiles in alpine skiing [2,3]
- ▶ Alpine skiing: high risk for severe injury (38.3 per 100 athletes per season, from those injuries 68% affect lower extremity) [1]
- ▶ Return to sport (RTS) test, similar to sport-specific performance testing, recommended [4]
- ▶ Study Aim: support or refute subjective observations to improve the criterion-based decision-making process for RTS

Research question

- ▶ Do maximal and explosive strength differences exist in high-level alpine skiers after returning from lower extremity injury compared to non-injured skiers?

Follow-up questions:

- ▶ Do maximal and explosive strength values improve at the same rate during rehabilitation?
- ▶ Do restoration rates of maximal and explosive strength characteristics differ between males and females?

Methods

- ▶ 56 data sets
- ▶ Injury survey from 2018 to 2023
- ▶ Post-injured (p_INJ) (n = 24), non-injured (n_INJ) (n = 32)
- ▶ Retrospective analysis of group means from routine performance testing [5,6]
- ▶ Relative F_{max} in two different squat positions (F_{max_70}, F_{max_100})
- ▶ Relative P_{max} squat jump (SJ) and countermovement jump (CMJ) with 0% and 100% additional load
- ▶ Two measurements: before injury (T1), after athletes' RTS (T2)
- ▶ Group comparison of n_INJ & p_INJ at T1 and T2 as well as comparison of performance by sex



Fig. 1 & 2: Measurement of the bilateral isometric squat in the low position with 70° knee flexion on the force plate with a fixed bar. Explosive strength test with additional load.

So What

These results contribute to the improvement of rehabilitation after lower extremity injuries and prevention.

Results

Comparison of non-injured versus post-injured athletes after return to sport at T2:

Parameter	Group	n	N/kg, W/kg	SD	p	ES (r)	Difference
F _{max_70}	n_INJ	32	26.4	± 2.2	0.072	0.29	-3.8%
	p_INJ	23	25.4	± 2.7			
F _{max_100}	n_INJ	32	37.7	± 4.7	0.191	0.21	-5.3%
	p_INJ	22	35.7	± 3.6			
SJ_P _{max_0}	n_INJ	31	53.8	± 9.3	0.21	0.20	-5.7%
	p_INJ	23	50.7	± 7.8			
SJ_P _{max_100}	n_INJ	28	48.1	± 8.0	0.02*	0.38	-10.3%
	p_INJ	21	43.1	± 6.4			
CMJ_P _{max_0}	n_INJ	31	58.8	± 10.2	0.02*	0.38	-10.0%
	p_INJ	23	52.9	± 8.2			
CMJ_P _{max_100}	n_INJ	29	51.7	± 7.6	0.04*	0.35	-8.5%
	p_INJ	21	47.3	± 6.5			

Tab. 1: Descriptive data for each measurement parameter at T2 with the number (n), mean in relative values (N/kg or W/kg) and standard deviation (SD). Statistical results of group comparison. The significant differences, indicated by an asterisk and a value of p < 0.05, are highlighted and accompanied by the effect size (r).

Comparison of non-injured versus post-injured athletes before injury at T1:

Parameter	Group	n	N/kg, W/kg	SD	p	ES (r)	Difference
F _{max_70}	n_INJ	32	26.2	± 2.3	0.02*	0.36	-4.1%
	p_INJ	24	25.1	± 2.5			
F _{max_100}	n_INJ	29	37.5	± 4.4	0.435	0.13	-2.9%
	p_INJ	21	36.4	± 4.1			
SJ_P _{max_0}	n_INJ	32	54.0	± 7.2	0.16	0.23	-4.2%
	p_INJ	23	51.7	± 6.7			
SJ_P _{max_100}	n_INJ	26	49.1	± 6.1	0.05*	0.36	-7.7%
	p_INJ	17	45.3	± 6.9			
CMJ_P _{max_0}	n_INJ	32	58.3	± 8.5	0.09	0.27	-6.0%
	p_INJ	23	54.8	± 7.3			
CMJ_P _{max_100}	n_INJ	29	52.3	± 6.2	0.04*	0.39	-7.8%
	p_INJ	17	48.2	± 7.4			

Tab. 2: Descriptive data for each measurement parameter at T1 with the number (n), mean in relative values (N/kg or W/kg) and standard deviation (SD). Statistical results of group comparison. The significant differences, indicated by an asterisk and a value of p < 0.05, are highlighted and accompanied by the effect size (r).

Sex-specific performance differences at T2:

- ▶ F_{max}: F_{max_70} 7.8 – 13.8% lower in female as compared to male (p = 0.001 – 0.03, r = 0.44 – 0.80) (more pronounced effect for p_INJ)
- ▶ P_{max}: all P_{max} values (SJ & CMJ) 13.5 – 19.6% lower for females (p = 0.002 – 0.025, r = 0.54 – 0.82)

Discussion

- ▶ No group differences in all F_{max} measurements: as expected, examination after completion of rehabilitation, according to current guidelines [4]
- ▶ Persistent, lower values of P_{max} of p_INJ for the heavier loads in the SJ and all loads in the CMJ in a meaningful range, partial expected according to current literature [7]
- ▶ **Main finding: A chronological order of recovery of performance-relevant strength values after return from a severe lower limb injury (group comparison at T2):**

Maximal strength (F_{max})

Explosive strength (P_{max} – SJ)

Explosive strength (P_{max} – CMJ)

- ▶ Meaningful lower P_{max} values in highly loaded SJ and CMJ at T1: Unexpected finding, should be considered in preventive counseling
- ▶ Male and female restored strength abilities to a similar degree after injury
- ▶ Female generally appear less explosive than male for a given F_{max} [8]

Conclusions

- ▶ Differences in performance-relevant strength parameters exist between non-injured and post-injured elite alpine skiers after return to sport following severe lower extremity injury.
- ▶ These differences are meaningful and pronounced for explosive strength.
- ▶ Athletes who would later suffer a severe lower extremity injury demonstrated lower maximal and explosive strength before the injury.
- ▶ Sex differences in maximal and explosive strength between male and female athletes after returning to competitive sport are similar to non-injured athletes.