HIGHER ON-FIELD REHABILITATION WORKLOADS ARE ASSOCIATED WITH PRE-INJURY RTC

Picinini F[1,2], Della Villa F[1], Tallent J[3,4], Patterson SD[2], Galassi L[1], Nanni G[1], Olmo J[1], Stride M[1], Buckthorpe M[1,2]

[1]Isokinetic Medical Group, Education and Research Department, FIFA Medical Centre of Excellence, Bologna, Italy
[2]Faculty of Sport, Technology and Health Sciences, St Mary's University, Twickenham, London, UK
[3]School of Sport, Rehabilitation and Exercise Sciences, University of Essex, Colchester, UK
[4]Department of Physiotherapy, School of Primary and Allied Health Care, Faculty of Medicine, Nursing and Health Science, Monash University, Melbourne, Australia

Introduction

Returning to 11-a-side football after an anterior cruciate ligament (ACL) rupture with reconstruction (ACLR) remains challenging, with low return-to-competition (RTC) rates and high ACL re-injury risk in professional and amateur players [1]. Although workload is considered the main vehicle to increase physical robustness towards RTC [2], with Global Positioning System (GPS) and heart rate (HR) technologies increasingly used to quantify internal and external OFR loads [3], evidence remains limited on whether greater cumulative loads are associated with higher RTC rates and lower ACL reinjury risk. This study aimed to investigate associations between pre-/intra-/post-operative factors, OFR workload exposure, RTC at the pre-injury level, and ACL re-injury.

Methods

Two hundred and eighteen male 11-a-side football players (45 professional, 173 amateur; mean?SD: age, 23.1?5.8 years, height 179.6?6.4 cm, body mass 73.1?8.2 kg, BMI, 22.6?1.9; pre-injury Tegner, 8.6?1.1) undertaking ACL rehabilitation at Isokinetic Medical Group (Bologna, Italy; London, UK) were prospectively recruited between 2019 and 2023. All players followed a structured, criteria-based rehabilitation pathway culminating in a 5-stage OFR programme [2]. OFR sessions were monitored using 10-Hz GPS (Catapult S5/S7) and HR monitor (Polar H10), along with session RPE, to quantify internal and external workloads (RPE, Total distance, High-intensity distance, Peak speed, Acceleration/deceleration metrics, Time in HR zones). Follow-ups were conducted =2 years post-surgery to determine RTC outcomes and ACL re-injury. Descriptive statistics and between-group comparisons were performed by level of football. Level-adjusted univariate logistic regression models examined associations of pre-, intra-, and post-operative factors, and OFR workload-related variables with RTC at the same pre-injury level and with ACL re-injury. A stepwise-forward selection ($p = 0.01$ in, $p = 0.05$ out) identified significant predictors among variables. Collinearity was managed through reducing the predictor set, and model discrimination was assessed using AUC (SPSS v.30.NY.IBM Corporation).

Results

Follow-up data were available for 200 players (mean 32.5±11.0 months). 83% returned to competitive football, and 79% returned to the same pre-injury level. Mean time to RTT and RTC were 7.8±2.1 and 9.6±3.1 months, respectively, with professionals RTT earlier and accumulating more team training weeks before the first match (8.04±4.62 vs 5.13±3.67 weeks, $p<0.001$). Twenty-nine players (14%) sustained a subsequent ACL injury (48% ipsilateral graft rupture; 52% contralateral), occurring 12.8±6.6 months post-ACLR. Professionals accumulated greater workloads across most GPS- and HR-derived variables ($p<0.005$), with no difference in OFR weeks between groups. Differences between RTC versus no-RTC at the same pre-injury level, and pre-, intra-, and post-operative factors, and OFR workload-related associations with RTC are reported in Table 1. Players who RTC at the same pre-injury level commenced OFR earlier, accumulated greater OFR exposure (more sessions, higher weekly minutes and session frequency) and achieved superior OFR stages. All internal and external workload variables were significantly associated with increased RTC odds, except for RPE and tHR>85. In multivariable modelling, no single internal or external workload variable remained independently associated with RTC, although combined workload profiles showed acceptable discrimination (AUC=0.75). None of the investigated variables was associated with ACL re-injury.

Conclusions

79% of players returned to their pre-injury level of football. Professional footballers accumulated substantially higher OFR exposure and workloads than amateurs across a structured 5-stage OFR programme, which may have contributed to superior RTC rates, among other factors. Improved RTC outcomes at the pre-injury level were consistently associated with greater OFR progression and higher cumulative internal and external workload exposure, although no single workload variable independently predicted RTC when considered alongside others. OFR workloads did not explain secondary ACL injury risk. These findings support multi-variable workload profiling during late-stage rehabilitation as part of the return-to-performance decision-making process, while highlighting the need to integrate other determinants of re-injury risk.

Table 1 Differences between RTC and No RTC at the same pre-injury level of football

Measurements and Variables	RTC, n (%) or Mean ± SD			RTC vs No RTC
	Yes (n=158)	No (n=42)	*P* Value	OR: Yes RTC (95% CI)
Pre-operative measurements				
Age (years)	22.1±5.0	25.1±7.3	**.001**	**.909 (.857-.964)**
ACL injury mechanism				
Direct contact (n=45)	41 (26)	4 (10)	.070	-
Indirect contact (n=40)	32 (20)	8 (19)		
Non-contact (n=115)	85 (54)	30 (71)		
Time from injury to surgery (days)	21.3±39.4	17.5±31.9	.724	-
Intra-operative measurements				
ACL graft type				
Autograft BPTB (n=50)	44 (88)	6 (12)	.257	-
Autograft HT (n=347)	288 (83)	59 (17)		
Autograft QT (n=2)	2 (100)	0 (0)		
Allograft (n=2)	1 (50)	1 (50)		
Post-operative and OFR period measurements				
Time from surgery to rehab (days)	21.1±39.2	17.5±31.9	.974	-
Time to OFR from surgery (days)	169.9±59.6	219.7±96.1	**.001**	**.992 (.987-.997)**
Overall rehab volume (days)	228.7±67.3	276.4±100.8	**.004**	**.994 (.989-.998)**
Time to RTC (months)	9.5±3.1	10.5±3.1	.294	-
OFR max stage reached	4.3±0.8	3.5±0.9	**<0.001**	**2.28 (1.51-3.45)**
Total OFR duration (min)	1446±885	954±608	.014	-
Weekly OFR duration (min)	201±125	128±71	**.008**	**1.01 (1.00-1.02)**
Number of OFR sessions (n)	19±11	11±6	**.001**	**1.11 (1.04-1.17)**
Weekly OFR frequency (n)	2.4±1.2	1.5±0.8	**<0.001**	**2.50 (1.45-4.33)**
Internal and external workload variables				
RPE (au)	5.0±1.1	5.2±1.3	.795	-
TD (Km)	93.2±83.5	52.2±38.6	**.003**	**1.02 (1.00-1.03)**
HID (m)	2458±3008	794±1167	**.007**	**1.05 (1.01-1.09)**
PS ($Km.h^{-1}$)	26.4±3.3	24.2±2.6	**.002**	**1.20 (1.07-1.36)**
ACC (m)	2535±2475	1260±1590	**.009**	**1.02 (1.00-1.04)**
DEC (m)	776±751	439±509	**.017**	**1.06 (1.01-1.11)**
ACC-DEC (m)	3290±3193	1698±2076	**.011**	**1.03 (1.00-1.05)**
*t*HR70-85 (min)	427±325	261±216	**.007**	**1.13 (1.03-1.23)**
*t*HR>85 (min)	185±183	125±168	.112	-

References

1. Manojlovic M. et al., RTP and RTPerf After ACLR in Soccer Players: A Systematic Review. Sports Med. 2024 Aug;54(8):2097-2108.
2. Buckthorpe M. et al., On-field Rehabilitation Part 1: 4 Pillars of High-Quality On-field Rehabilitation. JOSPT. 2019 Aug;49(8):565-569.
3. Picinini F. et al., High Return to Competition Rate After On-Field Rehabilitation in Competitive Male Soccer Players After ACL Reconstruction: GPS Tracking in 100 Consecutive Cases. OJSM. 2025;13(3).