The Complexity and Non-Uniformity of Fatigue - Assessments of Single-Joint Strength During 6 Weeks of Pre-Season in Male Rugby Union Athletes

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Rugby Union | Pre-season | Single-Joint Strength

Headline

Team sport activity has been shown to elicit fatigue causing performance decrements and increased injury risk in athletes (6). Therefore, the ability to monitor and manage training and fatigue is of vital importance to ensure athlete well-being (1). In an attempt to make informed decisions about readiness to train and training prescription, practitioners seek methods that attempt to quantify the magnitude of fatigue throughout all phases of the season (17). Especially after off-seasons or more recently after pandemic induced lockdowns, the need to quantify an athlete's physical response is crucial, as previous workloads are often unknown. Numerous methods are available to assess an athlete's response to training, such as psychometric questionnaires, autonomic nervous system function, physical performance tests and biochemical markers (2, 3, 4). Multijoint isometric strength tests, such as the isometric mid-thigh pull or isometric squat, are commonly used as they are able to deliver instantaneous feedback with minimal strain and a low injury risk compared to dynamic tests (5). During such multi-joint testing regimes, it is possible for the output to be unaffected or masked due to the ability to draw from different muscle groups in the kinetic chain and still produce reliable results (9). Therefore, single joint testing regimes might offer more meaningful findings about how each athlete is producing a maximal physical output.

Aim

The aim of this project was to quantify changes in single-joint force output during a six week pre-season training period following a ten week pandemic-induced lockdown within semi-professional male Rugby Union athletes. This will provide useful insights to practitioners about the practicability of different single-joint strength test for Rugby Union athletes to assess fatigue.

Methods

Athletes. Twenty-eight male Rugby Union players (21.1 ± 3.6 y; 185.4 ± 6.7 cm; 103.7 ± 15.1 kg; 5-9 h.week-1 skill practise; 2-4 h.week-1 resistance training; 2-4 h.week-1 conditioning) participated in this project. Participants were fully informed of all experimental procedures before giving their informed consent to participate.

Design. A within-group repeated measures design was used to quantify the magnitude of change in single-joint strength properties during the first six weeks of the pre-season. Five single-joint strength testing regimes were conducted: Nordbord knee flexor strength (NB), hip adduction (ADD), hip abduction (ABD), shoulder internal rotation (INT) and shoulder external rotation (EXT). Data was collected on four testing days (Day 0, Day 14, Day 28, Day 42) over the course of 6 weeks as part of regular monitoring in two week intervals. All participants were familiar with the testing procedures. All measures were collected before resistance trainings session. In total 14 athletes performed the NB testing, 22 performed ADD and ABD and 13 performed INT and EXT, respectively.

Methodology. All testing regimes were conducted as previously described (11, 12, 16). In short, after a standardised warm up and one submaximal test-specific trial all participants repeated three maximal trial with a 30-60 second passive rest in between each trial. All testing regimes captured the output for each limb. Outputs were summed for further analysis. Only the trial with the highest force output was used for further analysis. Every athlete was tested on the same weekday on the four testing days, which however, differed between athletes.

Analysis

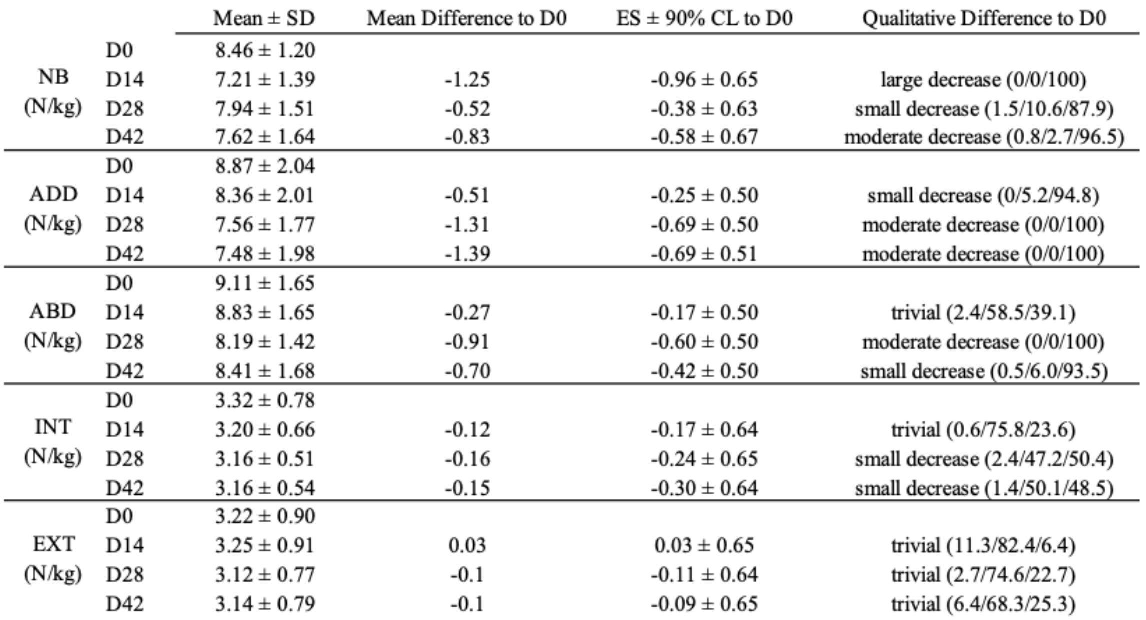
The mean ± SD were calculated using standard statistical methods for each of the four time points across the testing period. Cohens d effect sizes (ES) were calculated with 90% confidence intervals (CI) and interpreted as trivial (<0.2), small (0.2 - 0.49), moderate (0.5 - 0.79), large (>0.8) using magnitude-based inferences (10). These magnitudes were further interpreted using the following qualitative descriptions; $<$ 0.5% most unlikely, 0.5-5% very unlikely, 5-25% unlikely, 25-75% possibly, 75-95% likely, 95- 99.5% very likely, and $>$ 99.5% most likely (10).

Results

Descriptive and qualitative data for all tests are presented in table 1. Percentage change in single-joint strength for all tests is displayed in figure 1.

Discussion

The objective of the project was to describe the changes in single-joint strength during a 6 week pre-season in male semi-professional Rugby Union athletes. The main findings from this project showed moderate to large decreases in lower body single-joint force output during one or more testing occasions, whereas upper body single-joint force output showed, at best, a small reduction in force output.



		Mean ± SD	Mean Difference to D0	ES ± 90% CL to D0	Qualitative Difference to D0
NB (N/kg)	D0	8.46 ± 1.20			
	D14	7.21 ± 1.39	-1.25	-0.96 ± 0.65	large decrease (0/0/100)
	D28	7.94 ± 1.51	-0.52	-0.38 ± 0.63	small decrease (1.5/10.6/87.9)
	D42	7.62 ± 1.64	-0.83	-0.58 ± 0.67	moderate decrease (0.8/2.7/96.5)
ADD (N/kg)	D0	8.87 ± 2.04			
	D14	8.36 ± 2.01	-0.51	-0.25 ± 0.50	small decrease (0/5.2/94.8)
	D28	7.56 ± 1.77	-1.31	-0.69 ± 0.50	moderate decrease (0/0/100)
	D42	7.48 ± 1.98	-1.39	-0.69 ± 0.51	moderate decrease (0/0/100)
ABD (N/kg)	D0	9.11 ± 1.65			
	D14	8.83 ± 1.65	-0.27	-0.17 ± 0.50	trivial (2.4/58.5/39.1)
	D28	8.19 ± 1.42	-0.91	-0.60 ± 0.50	moderate decrease (0/0/100)
	D42	8.41 ± 1.68	-0.70	-0.42 ± 0.50	small decrease (0.5/6.0/93.5)
INT (N/kg)	D0	3.32 ± 0.78			
	D14	3.20 ± 0.66	-0.12	-0.17 ± 0.64	trivial (0.6/75.8/23.6)
	D28	3.16 ± 0.51	-0.16	-0.24 ± 0.65	small decrease (2.4/47.2/50.4)
	D42	3.16 ± 0.54	-0.15	-0.30 ± 0.64	small decrease (1.4/50.1/48.5)
EXT (N/kg)	D0	3.22 ± 0.90			
	D14	3.25 ± 0.91	0.03	0.03 ± 0.65	trivial (11.3/82.4/6.4)
	D28	3.12 ± 0.77	-0.1	-0.11 ± 0.64	trivial (2.7/74.6/22.7)
	D42	3.14 ± 0.79	-0.1	-0.09 ± 0.65	trivial (6.4/68.3/25.3)

Fig. 1. Table 1. Descriptive data is presented as mean ± SD, mean differences, effect sizes (ES) ± 90% confidence limits (CL) and qualitative differences are presented compared to D0. NB = Nordbord; ADD = hip adduction; ABD = hip abduction; INT = internal shoulder rotation; EXT = shoulder internal rotation. D0 = Day 0; D14 = Day 14; D28 = Day 28, D42 = Day 42.

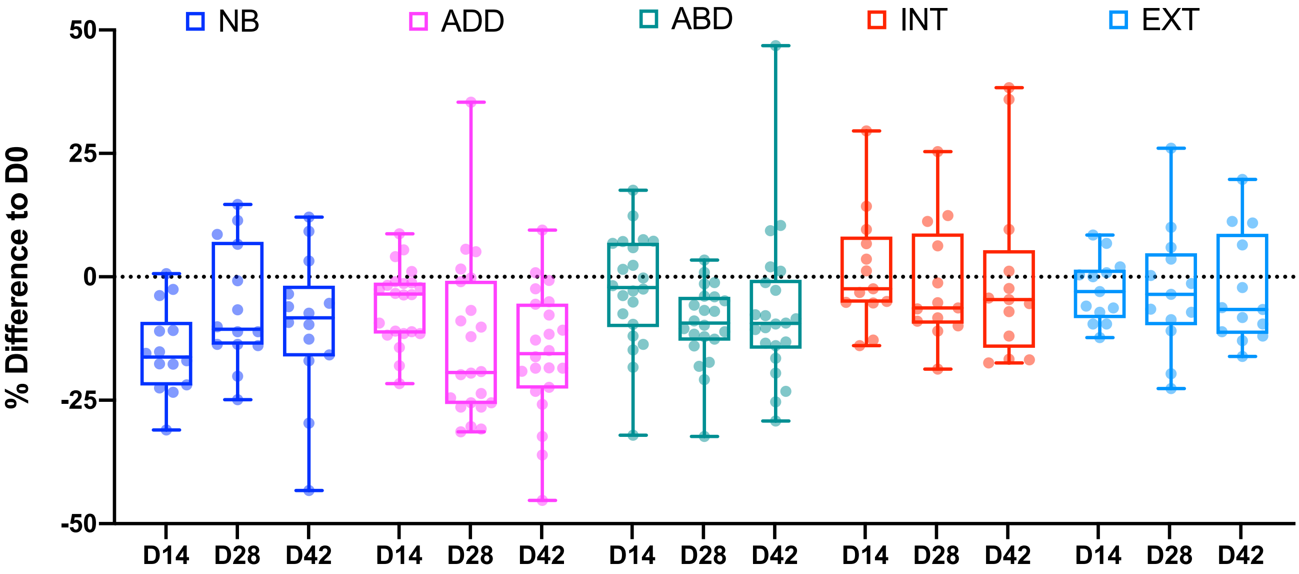


Fig. 2. Percentual difference between all single-joint tests compared to D0 are presented as box and whisker plots with individual data points. NB = Nordbord; ADD = hip adduction; ABD = hip abduction; INT = internal shoulder rotation; EXT = shoulder internal rotation. D0 = Day 0; D14 = Day 14; D28 = Day 28, D42 = Day 42.

Although, decreased single-joint strength capacities were expected based on the Bannister fitness-fatigue model (1), especially during early stages in the pre-season (i.e. D14), a supercompensation was not be reported during later stages (i.e. D28 and D42). Moreover, a sustained decrease in lower body single-joint strength in combination with progressively increased training loads during the pre-season can manifest itself in a greater injury risk as the imposed loads might exceed tissue tolerance. In particular, the hamstrings and adductors have been reported to be prone to acute or chronic injuries in invasive field sports (14, 15). It is possible that either acute fatigue from preceding training sessions masked the testing results or that the relationship of training and recovery was inadequate for this cohort, leaving them with chronically supressed single-joint strength capacities. However, from the current data set a definitive conclusion cannot be inferred and further research is needed to quantify the effect of single-joint strength on performance and injury-risk.

Another interesting finding was the non-uniform fatigue pattern observed in the lower limb, with the greatest decrease detected at different testing days. The biggest reduction in the NB, ADD and ABD occurred at D14, D28 and D42 as well as D28, respectively. This highlights how distinct systems of the body respond differently to the same training load. Such non-uniform stress-responses further emphasise the complexity practitioners face when looking to objectively quantify fatigue and/or readiness for each athlete in order to inform subsequent training load. While many methods are available to assess athlete readiness, practitioners should be cautious when relying on one distinct measure and possible incorrect inference. Meaningful variability exists within distinct lower-limb single-joint strength outputs, as demonstrated here, or within other commonly tested sub-systems (7, 8, 13). Finally, there was a great deal of intra-individual variability of single-joint strength output with certain athletes demonstrating a super-compensation pattern, despite the group average reporting a meaningful suppression of output. This emphasises the need to individualise the testing and training approach. Understanding the fatigue pattern of individual single-joint strength capacities can help practitioners inform their decision-making process in order to maximise athlete availability and performance.

Practical Applications

- This data can be used by practitioners to monitor and/or modify training throughout a pre-season.
- Relying only on single fatigue measurements can inaccurately reflect the athletes current state.
- Individualisation for testing and training is recommended to maximise athlete availability.

Limitation

- 14 days between each testing day might have been too broad to accurately detect the fatigue pattern.
- These observations are population specific. It remains unclear if they are generalisable to other athletic populations.
- The strength values are reported as force outputs (N) rather than joint torques (Nm) because it was not possible to measure limb lengths for all players at the time of testing.

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