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Manuscript Title: The effects of an 8-week off-season period on the mechanical properties of sprinting in professional rugby league players: implications for training considerations.

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ABSTRACT

Objective: To determine the change in mechanical properties of sprinting performance across an 8-week off-season period in professional rugby league players.

Design: Repeated measures

Methods: Twenty-six professional rugby league players from a single rugby league team competing in Super League completed two assessments of linear sprint performance during final week of the season and second week of preseason. Linear split times were used to model the horizontal force-velocity profile and determine theoretical maximal force (F_0), velocity (V_0) and power (P_{max}).

Results: Our result indicated moderate-to-large increases in split times was observed at each distance across the off-season period (ES = 0.86 to 1.24; *most likely*), indicative of a reduced sprinting ability. Furthermore, small reductions in F_0 (ES -0.34 to -0.57; *likely* to *very likely*) were observed, whilst the reduction in V_0 (ES = -0.81; *most likely*) and P_{max} (ES = -0.62 to -1.03; *most likely*) were considered moderate in magnitude.

Conclusions: An 8-week off-season period elicited negative changes in linear sprint times and the horizontal force-velocity profile of professional rugby league players. Such findings might have implications for preseason training loads and therefore, the off-season period requires careful consideration by practitioners and clinicians with regards to content and monitoring.

Keywords: Detraining, Force-Velocity Profiling, Sprint Mechanics, Collision Sport, Hamstring Injury

INTRODUCTION

The long-term cyclical programming of training in professional rugby league consists of three distinct phases; preseason, in-season and off-season. The preseason and in-season periods possess distinct purposes where adaptation and between-match recovery are the key focus, respectively. Whilst the pre- and in-season changes in anthropometric and physical characteristics have received attention in rugby league,[1] less focus has been given to the off-season period, which represents an important but overlooked phase of the season.[2,3] During this period, a substantial reduction or complete cessation of training occurs in an attempt to facilitate recovery and mental regeneration,[3] though often varies in duration and magnitude of reduction in training stimulus[4] across athletes, teams and sports with little consideration or understanding of the leisure-time activity practiced by athletes.

Whilst short periods of recovery (i.e. 1-3-week taper) can have a positive effect on performance, a prolonged off-season can result in detraining where physiological and neuromuscular adaptation is partially or completely lost,[3,5,6] impacting on several anthropometric and physical characteristics. For example, previous studies have demonstrated the negative effect an off-season period on body composition, aerobic capacity, repeated sprint ability, lower-body strength and power.[2,7] Of particular interest is the observed changes in linear sprinting performance following a period of detraining.[2,3,7] For example, an increase in mean 40 m sprint times ($P = 0.01$) have been observed after a 6-week off-season period in professional soccer players with a mean percentage increase of 1.8 ± 1.2.[2] Whilst changes in the group mean have been observed, the individual variability in response requires consideration, with no studies reporting the individual variability in response to a period of detraining in rugby league though large variability has been observed after a short period of training.[8] Furthermore, recent advancement in techniques has enables sport scientists to understand the mechanical properties of linear sprint using a field-based method, providing measures of horizontal force, power and velocity. Such information provides important insight into the contributors of overall sprint performance and understand which of these characteristics are affected by an off-season period, enabling focused training practices.

The observed reduction in physical characteristics such as sprint performance, might have important implications for return to training preparedness and performance during the early phases of preseason. The reduced training during the off-season period might result in greater physiological and biomechanical loads during the early preseason and a delayed exposure to high-intensity rugby-related activities.[3] Furthermore, the lack of sprinting performance might have important implications for injury risk,[9] with the preseason representing a high-risk period for injuries such hamstring strains.[10,] The association between sprinting and hamstring injury provides a potential explanation for the high prevalence observed in preseason.[10] Despite this, there is currently a lack of understanding around the changes in mechanical factors associated with sprinting performance during a prolonged period of detraining in rugby league players. Therefore, the aim of this study was to determine changes in mechanical properties of sprinting across an off-season period taking into account the individual variability in response.

METHODS

With ethical approval from the University of Chester and informed consent, 26 professional male rugby league players (age = 20.5 ± 2.9 years; stature 179.4 ± 5.9 cm; body mass = 87.5 ± 11.8 kg) participated in this study.

Using a repeated study design, players completed two assessments of linear sprint performance over a 30 m course during final week of the competitive Super League season (August) and second week of preseason (October). Players started each sprint in a two-point stance 0.3 m being behind an electronic timing gate system (Brower, Speedtrap 2, Brower, Timing Systems, Draper, UT, USA) positioned 150 cm apart, at a height of 90 cm and at distances of 0, 5, 10, 15, 20 and 30 m. Split times were recorded to the nearest 0.01 s with the lowest (fastest) 30 m time and corresponding splits used for analysis. A training programme was provided to the players for the off-season which include 4 weekly sessions focused on maintaining cardiovascular fitness and strength/power. Cardiovascular sessions generally included long- (i.e. 2 x 20 minuets steady-state) and shorter interval sessions (5 x 4 minutes intervals with 3 minutes recovery). Strength/power sessions generally included 2-3 sessions of balance, cores and functional training, and 2 lower- and upper-body strength sessions.

To determine the mechanical properties, all split times were initially corrected to account for the differences in instantaneous change in velocity and triggering of the timing gates. To attain this value, we recorded 13 sprints using a high-speed camera sampling at 300 fps (Quintic Consultancy Ltd, Coventry, UK). Total time was determined frame-by-frame the time from initial movement of the participant to the triggering of the first timing gate, providing a standardised mean value of 0.207 s. The mechanical properties of sprinting including maximal theoretical velocity (V_0), force (F_0) values, its corresponding maximal power output (P_{max}), maximal ratio of force (RF_{max}) and rate of decrease in RF (D_{RF}), were obtained using a validated method from speed-time data.[11,12]

All data is presented as mean and standard deviation. To compare the differences in split times and mechanical properties, Cohen's d effect sizes with 95% compatibility intervals (CI) were used with the follow thresholds applied: 0.0-0.2, trivial; 0.2-0.6, small; 0.6-1.2, moderate; 1.2-2.0, large; >2.0, very large.[13] Magnitude-based decisions were also included to provide a mechanistic inference using post-only cross over spreadsheet[14] and the following thresholds: 25% to 75% (*possibly*), 75% to 95% (*likely*), 95% to 99.5% (*very likely*) and >99.5% (*most likely*). When the CI overlapped both substantially positive and negative thresholds, differences were considered *unclear*.

RESULTS

Participants stature (-0.04 ± 0.05; *most likely trivial*) and body mass (0.13 ± 0.12; *likely trivial*) were not substantially different between assessments. Sprint times were *most likely* higher and individual split times were *possibly* to *most likely* higher across each gate position indicating small to large impairment in sprint performance when compared to the end of season (Table 1).

****INSERT TABLE 1 ABOUT HERE****

The mechanical properties associated with the sprint assessment indicated a small *likely to very likely* reduction in F_0 and moderate *most likely* reductions in V_0, P_{max} and RF_{peak} (Table 1). No clear difference was observed in D_{RF} (Table 1). Peak velocity was *most likely* (moderate) lower during the preseason assessment (Table 1). The individual responses to the off-season period indicated changes in F_0 of 0.1 to -2.2 $N \cdot kg^{-1}$, V_0 of 0.20 to -1.90 $m \cdot s^{-1}$ and P_{max} of -0.4 to -0.5 $W \cdot kg^{-1}$ (Figure 1).

****INSERT FIGURE 1 ABOUT HERE****

DISCUSSION

This study reported the changes in mechanical properties of sprinting in rugby league players across an off-season period, with the results indicating that an 8-week off-season period negatively impacts on the mechanical properties of linear sprinting in professional rugby league players. The result also highlighted a high degree of variability in changes in F_0, V_0 and P_{max}.

In agreement with previous research, we observed small-to-large increases in total split times as well as individual splits across all distances,[2,7] suggesting players returned to preseason training with impaired sprinting ability. The magnitude of increase in split times exceeded the typical error and smallest worthwhile change combined at 10 m (0.08 *cf.* 0.06 s), 20 m (0.15 *cf.* 0.08) and 30 m (0.21 *cf.* 0.11 s),[15] providing at least 75% confidence the change is true and worthwhile.[16] Interestingly, the magnitude of difference between the end-of-season and preseason appears to increase over distance (Table 1) and is reflective of a small increase in time between each of the splits compared to the end-of-season assessment (Table 1). Collectively, these findings indicate that a period of 8 weeks of little or no training negatively impacts on rugby league player's ability to generate forward orientation of ground reaction forces. Our results also suggest that player's peak velocity was lower during the preseason period when compared to the in-season assessments, indicative of a reduction the horizontal force applied at higher speeds.[11] Such findings are likely due to impaired muscle activation, neural adjustments (e.g. neural drive), altered muscle contractility and a reduction in fast twitch fibre cross-sectional area that occur with detraining.[5]

In relation to the mechanical properties, our results demonstrate that absolute and relative F_0, was impaired after the off-season period as was the proportion of force directed in a forward direction (expressed through RF_{max}). Similarly, we observed a moderate reduction in V_0, reaffirming that players' ability to generate force at high velocities was impaired following 8-weeks of detraining. Interestingly, the unclear change in D_{RF} suggests the difference in mechanical effectiveness with increasing speed was similar between sessions.[11] For the first time, we report a large degree of variability in the change in F_0 and V_0 which might reflect differences in time-courses responses of the skeletal muscle to detraining (i.e. cross-sectional area, fibres type, loss of muscle mass) and muscle performance losses.[17] The reduction in both force and velocity ultimately resulted in a moderate and systematic reduction in P_{max} (Table 1). The impaired mechanical properties of sprinting are likely explained by both neural and morphological changes within the skeletal muscle after a period of detraining such as loss of muscle mass,[11] reduced cross-sectional area of type II muscle fibres and motor unit recruitment;[5,7,17] all of which, affect participants' ability to generate maximal force and might have implications for injury, particularly when considering the need to generate a high degree of ground reaction force during actions such as cutting.

The result presented in this study have important implications for practitioners and clinicians working in rugby league whereby players arrive for preseason training with a lack of ability to generate high horizontal force, velocity and power. As such, a conservative approach is often taken before exposing players to any high-intensity actions; thus, meaning players require additional physical preparation that might impact on other aspects of performance including technical such as the kick-chase and tactical organisation due to slower positioning as well as potentially delaying overall development of players across multiple seasons.[3] Furthermore, due to the lack of training, the early weeks of preseason places players as high risk of injury,[4] particularly with reference to the hamstring strains[10] that may be associated with the impaired mechanical properties of sprinting.

Our result provide evidence to for the need practitioners working in professional sport to consider low-load training modalities that can be completed during the off-season. Focus on the off-season might prove beneficial and be used an opportunity to further develop players whilst allowing sufficient recovery.[3] For example, several researchers have demonstrated the effectiveness of short-duration interventions consisting of sprint interval,[18] repeated sprint[8] and/or speed and agility sessions[19] across a 2-4-week period are effective for improving linear sprint performance can might be considered by coaches as a simply and efficient modality of training. Furthermore, the inclusion weight-based, plyometric or sled training is also reported to improve or at least maintain linear sprint performance in soccer players.[20] Whilst these training modalities are effective, their impact on the players recovery during of the off-season is unknown, and we therefore suggest further research to be completed determining the role effects of off-season training whilst considering the recovery needs.

Whilst we provide some insight into the mechanical changes of sprint performance this study is not without limitations. Indeed, we were unable to document the off-season training performed by players, though we suspect this was minimal if any at all. Further, the use of timing gates is a potential limitation due to them not capturing instantaneous movement, though we did correct for this by applying a standard value to all split times to avoid the overestimation in F_0 and P_{max}.

CONCLUSION

In conclusion, this study provide insight into the changes in sprint times and associated mechanical factors across an off-season period in professional rugby league players. The result show times at distances of 5, 10, 15, 20 and 30 m increased as did the individual split times. Further, force, velocity and power were impaired after 8 weeks of detraining. Overall, our result support the provision of a structured off-season programme focused on maintaining the mechanical properties of sprinting (i.e. including maximal acceleration or sprint work) to support preparations for the preseason training loads (intensity and/or volume). Therefore, practitioners and clinicians are encouraged to explore the efficacy of off-season training programmes that allow for adequate recovery whilst also providing a sufficient stimulus.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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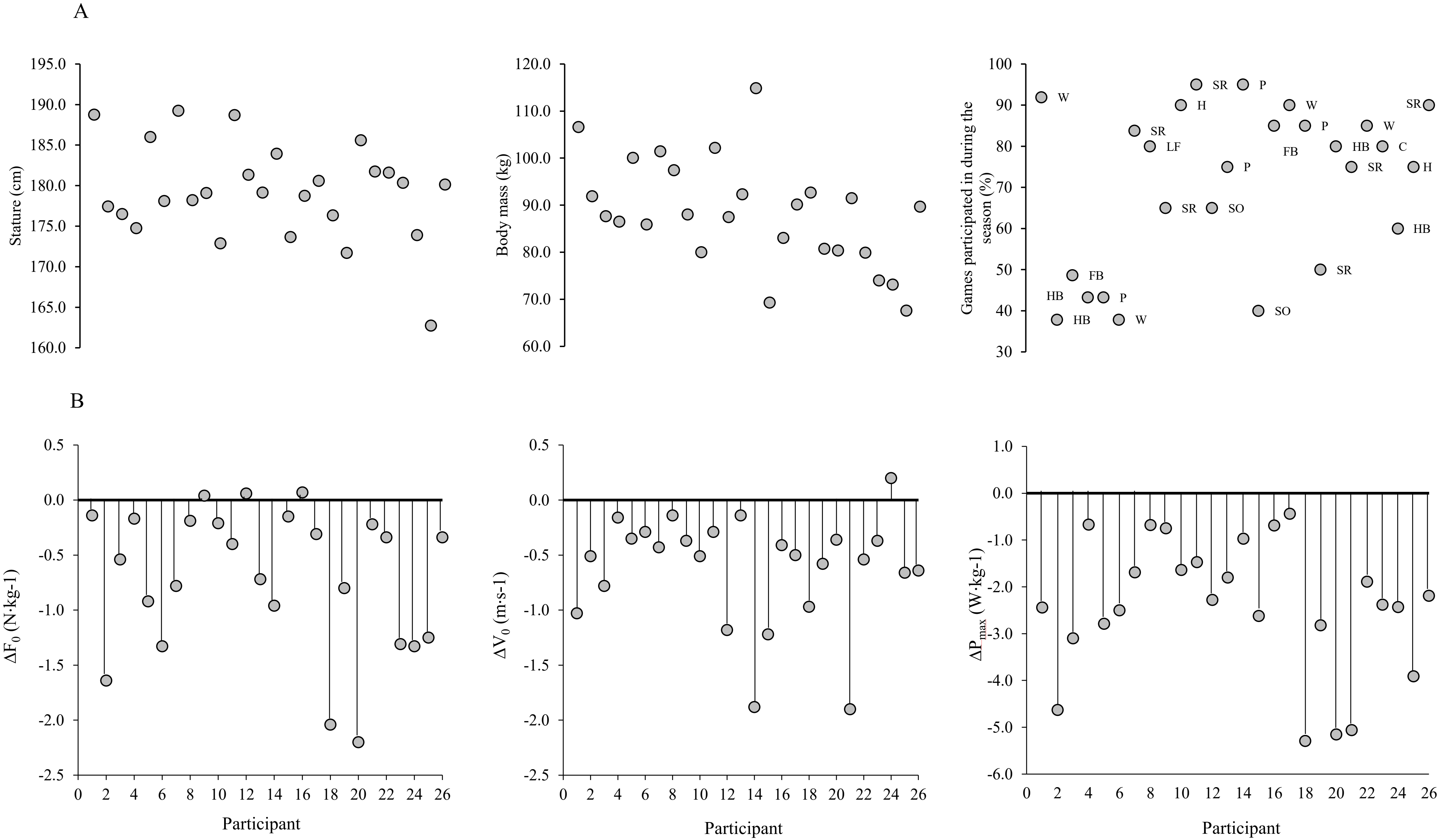
Table 1. Split times and mechanical properties of professional rugby league players pre and post an off-season period.

	End of Season	Pre-season	ES ± 95%CI	Inference
Split Times				
5 m (s)	1.28 ± 0.07	1.34 ± 0.07	0.86 ± 0.37	Moderate****
10 m (s)	2.01 ± 0.08	2.09 ± 0.08	1.03 ± 0.38	Moderate****
15 m (s)	2.66 ± 0.10	2.77 ± 0.11	1.09 ± 0.45	Moderate****
20 m (s)	3.27 ± 0.13	3.42 ± 0.14	1.14 ± 0.48	Moderate****
30 m (s)	4.44 ± 0.17	4.65 ± 0.21	1.24 ± 0.50	Large****
Δ5-10 m (s)	0.73 ± 0.04	0.76 ± 0.04	0.68 ± 0.33	Moderate***
Δ10-15 m	0.65 ± 0.05	0.67 ± 0.05	0.34 ± 0.44	Small*
Δ15-20 m	0.61 ± 0.04	0.65 ± 0.07	0.91 ± 0.51	Moderate**
Δ20-30 m	1.17 ± 0.06	1.23 ± 0.09	0.94 ± 0.30	Moderate****
Mechanical Properties				
F_0 (N)	761.8 ± 112.5	722.6 ± 107.1	-0.34 ± 0.24	Small**
F_0 ($N\cdot kg^{-1}$)	8.8 ± 1.1	8.1 ± 0.8	-0.57 ± 0.31	Small***
V_0 ($m\cdot s^{-1}$)	9.1 ± 0.6	8.6 ± 0.7	-0.81 ± 0.43	Moderate****
P_{max} (W)	1726.8 ± 277.2	1549.0 ± 248.7	-0.62 ± 0.25	Moderate****
P_{max} ($W\cdot kg^{-1}$)	19.8 ± 2.2	17.4 ± 2.1	-1.03 ± 0.39	Moderate****
RF_{max}	47.3 ± 2.3	45.2 ± 2.2	-0.92 ± 0.38	Moderate****
D_{RF}	-8.9 ± 1.5	-8.9 ± 1.3	0.03 ± 0.31	Unclear
Peak velocity ($m\cdot s^{-1}$)	8.6 ± 0.5	8.1 ± 0.5	-0.85 ± 0.27	Moderate****

*F_0 = theoretical peak force = V0 = theoretical peak velocity, P_{max} = maximal power output, RF_{peak} = peak ratio of force, D_{RF} = rate of decrease in the ratio of force. * = possibly, ** = likely, *** = very likely, **** = most likely.*

Figure 1. Individual participants characteristics, percentage of games participated in with playing position (panel A) and the individual changes for theoretical optimal force (F_0; left), theoretical optimal velocity (V_0; middle) and maximum power (P_{max}; right) (panel B).

Note: Data in panel A is presented and mean and percentage of games participated in. Data in panel B reflect the change in variable across the off-season period. H = Hooker, P = prop, HB = halfback, FB = fullback, SR = second row, SO = stand-off, W = winger, C = centre, LF = loose forward.


A
Stature (cm)
195.0
190.0
185.0
180.0
175.0
170.0
165.0
160.0
Body mass (kg)
120.0
110.0
100.0
90.0
80.0
70.0
60.0
Games participated in during the season (%)
100
90
80
70
60
50
40
30
W
SR
P
H
W
SR
SR
LF
P
FB
W
P
HB
C
P
SR
H
SR
SO
HB
FB
HB
P
SR
HB
W
SO
B
ΔF0 (N·kg-1)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
ΔV0 (m·s-1)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
ΔPmax (W·kg-1)
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Participant
Participant
Participant