Title: The internal and external responses to a forward-specific rugby league simulation protocol performed with and without physical contact.

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Abstract

It is important to understand to what extent physical contact changes the internal and external load during rugby simulations that aim to replicate the demands of match play. Accordingly, this study examined the role of physical contact on the physiological and perceptual demands during and immediately after a simulated rugby league match. Nineteen male rugby players completed a ‘contact’ (CON) and a ‘non-contact’ (NCON) version of the rugby league match simulation protocol (RLMSP-i) in a randomized crossover design with one week between trials. Relative distance covered (ES = 1.27; ±0.29), low intensity activity (ES = 1.13; ±0.31), high-intensity running (ES = 0.49; ±0.34), heart rate (ES = 0.52; ±0.35), blood lactate concentration (ES = 0.78; ±0.34), RPE (ES = 0.72; ±0.38) and session RPE (ES = 1.45; ±0.51) were all higher in the CON compared to the NCON trial. However, peak speeds were lower in the CON trial (ES = -0.99; ±0.40) despite unclear reductions in knee extensor (ES = 0.19; ±0.40) and knee flexor (ES = 0.07; ±0.43) torque. Muscle soreness was also greater after CON compared to the NCON trial (ES = 0.97; ±0.55). The addition of physical contact to the movement demands of a simulated rugby league match increases many of the external and internal demands, but also results in players slowing their peak running speed during sprints. These findings highlight the importance of including contacts in simulation protocols and training practices designed to replicate the demands of real match play.

Keywords: Collision; fatigue; pacing, intermittent

Introduction

The large inter-match variability observed in high and very-high intensity running during rugby league matches[1] means that investigators would have to analyze performances over many matches in order to detect real systematic changes in performance. Accordingly, the use of reliable simulation protocols that reflect the movement and physiological demands observed during competitive matches[2] enable researchers to assess the effectiveness of various interventions (e.g. training or dietary) with greater confidence.[3] Such protocols have been described previously for rugby league,[4,5] and replicate the players' typical movement patterns during a match when the ball is in and out of play.

In the protocol described by Waldron and colleagues,[5] the overall internal and external demands were similar to that described during actual match play.[6] However, as detailed analysis of a player's movement profile over successive quartiles was not reported, it is unclear whether this simulation protocol provides a valid means of replicating actual match play. In particular, reductions in high intensity running over progressive match quartiles has been reported during actual match play[1,6,7] and are indicative of fatigue that is mediated by both central and peripheral factors.[6,8,9,10,11]

What remains less clear is the role that physical contact plays in the fatigue response associated with contact sports. Physical contact increases total running time, heart rate and rating of perceived exertion when added to repeated sprint exercise.[12] Johnston and colleagues have also reported alterations in rugby league players' movement characteristics when contact was added to training-based games,[13] and that greater reductions in running intensity occur when the number of contacts is increased. However, these findings were observed in short-duration, small-sided training games that do not replicate the duration and running demands associated with match play. While such studies indicate the internal and external load imposed on an individual is altered with the inclusion of contact, the specific contribution of this action to how a player fatigues during match related activity remains unclear.

It is important to understand the extent to which physical contact influences the internal and external load imposed on rugby players and its contribution to fatigue during prolonged intermittent activity. More specifically, including collisions in a rugby league simulation protocol improves the replication of real world demands and enables a better understanding of this activity within this important research model. Therefore, the purpose of this study was to assess the effects of physical contact on the movement, physiological, perceptual, and neuromuscular responses to a forward-specific simulated rugby league match.

Methods

Participants and design

After institutional ethical approval, 19 university rugby players familiar with the movement characteristics of rugby league forwards (age = 20.1 ± 1.3 y; body mass = 80.1 ± 8.3 kg; stature = 178.8 ± 0.1 cm; predicted $\dot{V}O_{2max}$ = 50.2 ± 3.4 $ml \cdot kg^{-1} \cdot min^{-1}$) were recruited for the study. All participants provided written informed consent and completed a pre-test health questionnaire before participating in the study. The study was a randomized cross-over design involving a contact (CON) and a non-contact (NCON) condition of a simulation protocol designed to replicate the movement demands imposed on interchanged rugby league players (RLMSP-i[5]). Participants were randomly allocated to either CON followed by NCON condition (*n*=10) or NCON followed by CON condition (*n*=9). Individual testing took place over 12 days with three days rest after baseline measurements and 7-10 days rest between the CON and NCON conditions. All testing was conducted at similar times of the day, according to two time slots (morning 9-11 am and afternoon 12-2 pm) for both conditions. The participants were also asked to refrain from strenuous activity for 24 h before each trial. Movement speeds using global positioning system (GPS), heart rate and perceived exertion were measured throughout each protocol. In addition, blood lactate concentration and muscle function were recorded before, at half-time and immediately after the RLMSP-i. Muscle soreness was also recorded on completion of the protocol. Environmental conditions were recorded (THG810, Oregon Scientific Ltd., Berkshire, UK) throughout the protocol, with no differences between the CON and NCON trials for temperature (8.2 ± 1.2 °C cf. 7.4 ± 1.1°C, p = 0.749) or relative humidity (55.2 ± 7.9% cf. 49.7 ± 10.1% relative humidity, p = 0.179), respectively.

Procedures

Baseline measurements and familiarization

The 20 m multi-stage fitness test (MSFT[14]) was performed in an indoor sports hall to estimate each participant's $\dot{V}O_{2max}$. Using the criteria outlined by Waldron et al.,[5] participants were required to possess an estimated $\dot{V}O_{2max}$ >45 $ml·kg^{-1}·min^{-1}$ (Level 9 - MSFT) to participate. During this visit participants were also familiarized with the procedure used for countermovement jump (CMJ) performance, the isokinetic dynamometer (Biodex 3, Biodex Medical Sytems, Shirley, NY, USA) and completed two cycles of the RLMSP-i.

Rugby League Match Simulation Protocol

Before commencing the protocol, participants completed a standardized 10-minute warm up comprising varied intensities of running and dynamic stretching. Participants then performed the RLMSP-i on an artificial grass pitch according to the procedures described previously.[5] Participants ran alone to avoid any influence of others on the individual's pacing. Participants followed instructions from an audio signal that controlled movement speeds between coloured cones positioned over a 28.5 m linear track. These movements are based on the mean locomotive speeds and activities of interchanged players established during senior elite rugby league matches.[15] The RLMSP-i lasted 42.86 min (2 x 21.43 min separated by 20 min), replicating the average time that a forward spends on the pitch during a match.[7,16]

Each participant was given specific instructions of how to complete a contact during the RLMSP-i, which was accompanied with demonstrations performed by the researcher during familiarization. Contact was simulated with participants tackling a soft, cylindrical-shaped tackle bag (Gilbert Rugby, East Sussex, England; mass = 23 kg; dimensions = 138 x 45 cm) at 'maximal' intensity. The contact began with an 8 m sprint and tackling the bag with the shoulder at approximately hip height. At the point of contact, the participant was instructed to flex the hips, knees and ankles, whilst keeping both arms wrapped around the tackle bag. The bag was driven to the floor and the participant landed in a prone position, still grasping the bag. Once landed, the participant was instructed to roll 360º laterally whilst holding the bag, touching it on the floor, before rolling laterally 360º back to the original position. The contact was performed once per cycle. Players also performed a 'flapjack' movement once per cycle, requiring the participant to sprint 8 m drop from a standing to a prone position, and roll laterally 360º, before rolling back 360º to the original position and standing up. For the NCON condition, the contact began with an 8 m sprint, after which participants were required to drop to a prone position, count to 3 s then get on their feet. This was repeated for every ‘contact’, twice per cycle, throughout the RLMSP-i in the NCON condition. Each cycle of the RLMSP-i consists of two parts; the first (ball in play) lasting 60.32 s is performed twice and the second (ball out of play) lasting 48.25 s. The order of activity is as follows: 13.5 m sprint, 15 m jog (decelerate), 8 m sprint to contact, 7.0 s simulated contact, 20.5 m jog (ball in play), and 13.5 m walk x 2, 13.5 m jog, 13.5 m walk (ball out of play). This cycle is repeated 24 times (2 × 12 cycles) to simulate the match time of a forward, where a 20 min passive recovery is provided half way through to simulate both half time and substitution time. A schematic of the RLMSP-i and accompanying measurements is shown in Figure 1.

******* Insert Figure 1 about here *******

Movement demands and heart rate during the RLMSP-i

Participants were pre-fitted with an appropriately sized vest housing the portable GPS unit (SPI-Pro; 5Hz, GPSports, Canberra, Australia) between the scapulae. The GPS device sampled at a rate of 5 Hz and was integrated with a 6-g tri-axial accelerometer sampling at 100 Hz, with the participant wearing the same GPS unit for each trial. The participants’ heart rate (HR) was collected using a HR monitor (Polar Electro Oy, Kempele, Finland), which was fitted to the chest of the participant. Heart rates were later calculated as a percentage of each participant’s pre-determined peak heart rate (%HRpeak), defined as the highest heart rate achieved throughout all testing visits. Both movement and HR data were downloaded using SPI Ezy V2.1 (GPSports, Canberra, Australia) and analyzed using Team AMS V2.1 software (GPSports, Canberra, Australia). A digital watch was synchronized with Greenwich Mean Time and used to record the start and end of the protocol, as signalled by the CD player. These times were later used to truncate the raw GPS data file into quartiles of the first and second playing bouts. Data were then analyzed per playing quartile of each bout in the RLMSP-i, including relative distance covered ($m{\cdot}min^{-1}$), relative distance within low intensity activity (≤14.0 $km{\cdot}h^{-1}$), high-intensity running (>14.0 $km{\cdot}h^{-1}$), and peak running speed ($km{\cdot}h^{-1}$). The test-retest reliability coefficient of variation for the measurements of distance and speed by the GPS devices ranged from 1.8-2.1% and 1.9-2.1%, respectively.[17]

Muscle function

CMJ flight time was recorded using a portable jump mat (JustJump, Time-It, Eleiko Sport, Halmstad, Sweden). The jump began with the participant in an upright position with their hands on their hips, after which they rapidly flexed their knees to approximately 90° before jumping for maximal height. Participants were required to perform three jumps with the highest jump taken for analysis. The CMJ was performed immediately before starting the RLMSP-i, in the first 5 min of the 20 min passive recovery period (half-time) and immediately after finishing the protocol. In house determined test-retest reliability coefficient of variation for the measurement of CMJ flight time was 2.0%.

An isokinetic dynamometer (Biodex 3, Biodex Medical Sytems, Shirley, NY, USA) was used to measure knee extensor and flexor peak torques at 60 $deg{\cdot}s^{-1}$ in the participant’s dominant limb. The participant was fitted to the dynamometer according to the manufacturer’s guidelines of knee torque assessment, and the mass of the limb was recorded to enable gravitational correction of peak torque values. Visual feedback, displaying real-time force, was used to encourage maximal efforts and participants were consistently encouraged to exceed target values, based on those achieved during familiarization. Measurements were made 30 minutes before and between 20-30 minutes after finishing the protocol. In house determined test-retest reliability coefficient of variation for the measurement peak isokinetic extension and flexion torques was 4.2-6.8%.

Blood lactate concentration

Blood lactate concentration was assessed using a capillary blood sample from a fingertip. Whole blood samples were analysed immediately using a portable lactate analyser (Lactate Pro, Arkray, Kyoto, Japan). Blood lactate samples were collected 5 minutes before starting the protocol, immediately after the first bout and immediately after termination of each trial. In house determined test-retest reliability coefficient of variation for the measurement of lactate using this analyser was 8.2%.

Perceptual measures

Rating of perceived exertion (RPE[18]) was recorded during walking intervals after every quartile (5.36 min) in the first and second bout of the RLMSP-i. In house determined test-retest reliability coefficient of determination for the measurement RPE was 2.4%. Furthermore a session RPE[19], where individuals rated their perceived exertion for the entire session, was recorded 20 minutes after completion of the RLMSP-i. Muscle soreness of the lower body was recorded immediately before and after each trial using a visual analogue scale (VAS[20]). Participants were required to hold a squat with knees flexed at 90° and rate their muscle soreness on the 0 (no muscle soreness) to 10 (muscle too sore to move) scale.

Statistical Analysis

The assumption of a normal distribution was met according to the Shapiro-Wilk statistic. All data are presented as means ± standard deviation (SD). Separate repeated measures analysis of variance (ANOVA) or paired samples *t*-tests were applied, using an alpha level of <0.05, to detect differences between contact (CON) and non-contact (NCON) trials. Effect sizes (ES) and magnitude-based inferences, as suggested by Batterham and Hopkins,[21] were also calculated for all variables between CON and NCON trials. Thresholds for the magnitude of the observed change for each variable was determined as the between-participant SD in that variable x 0.2, 0.6 and 1.2 representative of a small, moderate and large effect, respectively.[22,23] Threshold probabilities for a meaningful effect based on the 90% confidence limits (CL) were: <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, >99.5% most likely. Effects with confidence limits across a likely small positive or negative change were classified as unclear.[23] Effect sizes and associated confidence intervals (CI) are denoted as ES; ±90%CI. All calculations were completed using a predesigned spreadsheet.[24]

Results

Movement demands

The external movement demands of the CON and NCON trials are shown in Table 1. Relative distance covered (ES = 1.27; ±0.29, *Most likely* ↑; p < 0.0001), low intensity activity (ES = 1.13; ±0.31, *Most likely* ↑; p < 0.0001) and high-intensity running (ES = 0.49; ±0.34, *Likely* ↑; p = 0.024) were all higher in the CON compared to the NCON trial. A condition x bout interaction (p = 0.016) also indicated higher relative distance covered during the second bout of the CON compared to the NCON condition. Peak speeds were lower in the CON compared to NCON trial (ES = -0.99; ±0.40, *Most likely* ↓; $p < 0.0001$), with a condition x bout x quartile interaction ($p = 0.001$) revealing differences in peak speed between conditions in the final three quartiles of the first and first three quartiles of the second bout, respectively.

****** *Insert Table 1 about here* ******

Physiological and perceptual measures

The heart rate and RPE responses to the CON and NCON trials are shown in Table 2. Relative heart rate (ES = 0.52; ±0.35, *Likely* ↑; $p = 0.018$) and RPE (ES = 0.72; ±0.38, *Very likely* ↑; $p = 0.004$) were higher in the CON compared to the NCON trial. Blood lactate concentration was also higher in the CON compared to NCON trial (ES = 0.78; ±0.34, *Most likely* ↑; $p = 0.001$), with a trial x time interaction ($p = 0.009$) revealing higher blood lactate concentration in the CON at half-time and the end of the simulation (Figure 1). Session rating of perceived exertion was higher for the CON (294.2 ± 65.3 AU) compared to the NCON trial (225.2 ± 45.7 AU; ES = 1.45; ±0.51, *Most likely* ↑; p = 0.018).

****** *Insert Table 2 about here* ******
****** *Insert Figure 2 about here* ******

Muscle function

The post-exercise reduction in knee extensor torque was *unclear* (ES = 0.19; ±0.40; p = 0.425), suggesting the decrement in CON (-4.2 ± 7.8%) was not different to that of NCON (-2.6 ± 5.3%). Similarly, reductions in knee flexor muscle force were also *unclear* after the CON (-7.2 ± 10.0%) and NCON (-6.4 ± 8.7%) trials (ES = 0.07; ±0.43; p = 0.775). Countermovement jump flight time was similar between CON (0.62 ± 0.03 s, 0.61 ± 0.03 s, 0.61 ± 0.03 s at pre, mid and post, respectively) and NCON (0.61 ± 0.02 s, 0.61 ± 0.03 s, 0.61 ± 0.03 s, at pre, mid and post, respectively) trials (p = 0.811). Muscle soreness was greater after CON (3.8 ± 1.2) compared to the NCON (2.6 ± 1.2) trial (ES = 0.97; ±0.55, *Very likely* ↑; p = 0.007).

Discussion

This study examined running, physiological and perceptual responses of players during a simulated rugby league match performed with and without physical contact. Greater total distance, low intensity activity, high intensity running, heart rate, blood lactate concentration and perceived exertion were observed when the simulation was completed with contact. However, including contact in a rugby league simulation protocol resulted in a lower peak speed attained whilst sprinting throughout the simulation. Reductions in neuromuscular function after each trial were small and similar for both conditions.

An increased external demand when contact was included during the simulation was unexpected and contradicts previous studies that have examined how collisions affect running performance during team sport activity.[13,25,26] The inclusion of contact in a match simulation resulted in more total distance covered, comprising increases in both low and high intensity running. In contrast, previous studies have observed that including physical contact to small-sided rugby games reduces total distance, caused predominantly by players engaging in less low intensity running.[13] Such findings are indicative of players adopting pacing strategies that enable the preservation of fundamental high intensity activities (e.g. tackling, sprinting) when faced with additional fatiguing tasks. However, this does not seem to be the case when such tasks are introduced to an externally regulated rugby league simulation protocol. Instead, a greater distance in a simulation is probably explained by the increased movement demands associated with approaching, tackling and re-positioning the tackle bag.

Despite increases in the total distance covered and how this was achieved, peak running speed is *likely* to *very likely* lower during the RLMSP-i when contacts have to be performed. This was most notable in the final three quartiles of the first bout and first three of the second bout. We propose that this reduction in peak speed, which is the only truly 'self-paced' element of the RLMSP-i, in the CON condition is consistent with the previously proposed notion of players pacing their movements to enable completion of fundamental skills or activities.[13,27,28] Reductions in peak sprint speed did not accompany contemporaneous changes in peak knee extensor and flexor torque, which were unclear and similar between both conditions. Flight time during CMJ remaining unchanged between and across trials, was an unanticipated finding given the changes in running performance. Whilst the CMJ is used frequently as a measure of lower limb neuromuscular fatigue with team sport athletes[13,16,25,29], no change in jump performance after prolonged intermittent running has been reported before.[30,31] This might be explained by a weak association between vertical jumping and horizontal sprint performance.[32] The relatively short duration of our protocol (~40 min) and that the simulated contact did not truly replicate the neuromuscular actions of real collisions might also be responsible. Finally, our finding that peak sprint speed was increased during the final quartile of the CON trial is consistent with the 'end spurt' phenomenon.[28] Thus, apparent changes in sprint performance were not explained by a failure of any physiological system, but rather a self-selected reduction of maximal running speed.

The findings from our study that heart rate, blood lactate concentration and RPE increased when contact was added to the simulation protocol are consistent with findings of Johnston and Gabbett[13] who added collisions to a repeated sprint protocol. However, a greater physiological response in the CON trial is in contrast to Singh and colleagues,[25] who reported no difference in the heart rate and perceived responses during a team sport simulation protocol performed with and without physical contact. While the contact used by Singh et al.[25] also involved participants hitting a tackle bag and going to ground, unlike our study there was no lateral rolling. This was used in our study to replicate the 'wrestle' typically observed in rugby league collisions, where defenders look to gain a dominant position when on the floor. Coupled with the increased movement, this additional demand within the collision situation probably explains the greater physiological strain in the simulation with contact.

The inclusion of physical contact resulted in relative distance covered, low intensity activity and high-intensity running being greater than values reported in actual match play.[6,15] Such differences are probably explained by our chosen method of contact. We speculate the running kinematics into contact in the simulation are faster than those in match play,[33] meaning the player is likely to approach the tackle bag with a higher velocity and greater acceleration than when running to collide with a human body. Discrepancies in running kinematics are also likely to contribute to the aforementioned differences between the CON and NCON trials. However, despite total and high intensity distance covered during the RLMSP-i being greater than that reported for Super League matches,[15] including physical contact in a simulation protocol better reflects the pattern of running performance and fatigue during a match when compared to a simulation without contact. Indeed, changes in the high-intensity running performance during the two ~20 min exercise bouts replicates the same pattern of decline demonstrated by players during competition.[6] That is, high-intensity running declined rapidly during the first bout until the player was removed, followed by a lower volume of high intensity running with a more subtle decline in the second bout.

Blood lactate concentrations observed in the simulation (~4.5 $mmol \cdot l^{-1}$) were lower when compared to values previously reported from matches (~5-8 $mmol \cdot l^{-1}$).[34] Again, we attribute these differences to our simulation of contact and the difficulties in trying to replicate collisions performed in matches. Compared to contact with a tackle bag, involvement in tackles with an opponent would be expected increase the metabolic strain on the neuromuscular system both from the deceleration into the contact and during the contact itself, i.e. 'the wrestle'. Indeed, higher blood lactate concentrations are reported during wrestling type activies[35] and during shuttle running with a greater number of accelerations and decelerations.[36]

Practical applications

How players approach intermittent running that mimics the movements associated with rugby league depends on whether physical contact is included or not. From a research perspective, the ability to accurately reflect the movement demands of match play using a simulation requires a careful consideration of the way in which collisions are replicated. However, practitioners should include simulated contacts to increase the internal and external load on players during training practices that address prolonged intermittent running.

Conclusion

The inclusion of physical contact to a rugby league simulation protocol increased overall, low and high intensity running demands, as well as the internal load experienced by players. However, lower peak speeds when collisions were performed suggest that pacing strategies differed depending on whether the simulation was performed with or without physical contact. While the findings of our study reaffirm the challenges of replicating physical contact within a team sport simulation protocol, the RLMSP-i goes some way to simulating the internal and external load of a real rugby league match. In addition, our findings confirm the importance of including contacts in simulation protocols and metabolic conditioning sessions designed to replicate the demands of real match play. Future studies should look to examine the types of contact employed in simulation protocols to further our understating of this important determinant of rugby league performance.

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Table 1. Mean ± SD relative distance, low intensity activity (<14 km·h⁻¹), high intensity running (≥14 km·h⁻¹), and peak speed (km·h⁻¹) distance for contact (CON) and non-contact trials (NCON). Data in italics are effect size ±90% CI and qualitative descriptor for CON vs. NCON comparisons.

	Bout 1				Bout 2			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Relative distance (m·min⁻¹)								
CON	114 ± 2	113 ± 3	113 ± 3	112 ± 4	112 ± 3	113 ± 3	113 ± 3	113 ± 3
NCON	110 ± 2	110 ± 2	110 ± 2	109 ± 3	107 ± 3	108 ± 4	108 ± 3	107 ± 4
	1.34; ±0.46	*1.18; ±0.48*	*1.00; ±0.46*	*0.88; ±0.46*	*1.29; ±0.21*	*1.03; ±0.29*	*1.30; ±0.31*	*1.34; ±0.25*
	Most likely ↑	*Most likely* ↑	*Very likely* ↑	*Very likely* ↑	*Most likely* ↑	*Most likely* ↑	*Most likely* ↑	*Most likely* ↑
Low intensity activity (m·min⁻¹)								
CON	84 ± 3	85 ± 3	85 ± 2	85 ± 4	85 ± 2	86 ± 3	86 ± 3	86 ± 2
NCON	82 ± 3	83 ± 3	83 ± 3	83 ± 2	83 ± 3	83 ± 3	83 ± 3	82 ± 3
	0.53; ±0.41	*0.96; ±0.48*	*0.69; ±0.42*	*1.00; ±0.54*	*0.97; ±0.22*	*1.16; ±0.32*	*1.07; ±0.36*	*1.28; ±0.28*
	Likely ↑	*Very likely* ↑	*Very likely* ↑	*Very likely* ↑	*Most likely* ↑	*Most likely* ↑	*Most likely* ↑	*Very likely* ↑
High intensity running (m·min⁻¹)								
CON	30 ± 3	28 ± 2	27 ± 3	27 ± 3	27 ± 2	26 ± 2	27 ± 2	27 ± 2
NCON	28 ± 4	27 ± 3	27 ± 2	26 ± 3	24 ± 2	25 ± 3	25 ± 3	25 ± 3
	0.39; ±0.33	*0.26; ±0.48*	*0.25; ±0.48*	*0.16; ±0.42*	*0.88; ±0.32*	*0.33; ±0.32*	*0.56; ±0.37*	*0.69; ±0.20*
	Likely ↑	*Unclear*	*Unclear*	*Unclear*	*Most likely* ↑	*Likely* ↑	*Likely* ↑	*Very likely* ↑
Peak speed (km·h⁻¹)								
CON	24.1 ± 1.2	23.3 ± 1.3	22.8 ± 1.7	22.5 ± 1.6	22.9 ± 1.8	23.0 ± 1.4	23.0 ± 1.6	23.6 ± 1.7
NCON	24.4 ± 0.9	24.3 ± 1.0	24.5 ± 1.3	24.1 ± 1.3	23.8 ± 1.3	24.0 ± 1.2	23.7 ± 1.3	24.1 ± 1.1
	-0.36; ±0.45	*-0.92; ±0.39*	*-1.20; ±0.52*	*-1.12; ±0.33*	*-1.23; ±0.55*	*-1.17; ±0.43*	*-0.53; ±0.38*	*-0.45; ±0.56*
	Possible ↓	*Most likely* ↓	*Most likely* ↓	*Most likely* ↓	*Likely* ↓	*Very likely* ↓	*Likely* ↓	*Likely* ↓

Q = quartile, ↑ = increase, ↓ = decrease

Table 2. Mean ± SD percentage heart rate peak and RPE for contact (CON) and non-contact trials (NCON). Data in italics are effect size; ±90% CI and qualitative descriptor for CON vs. NCON comparisons.

	Bout 1				**Bout 2**			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
HRpeak (%)								
CON	86.1 ± 5.4	88.5 ± 5	88.3 ± 5.2	87.9 ± 5.1	85.3 ± 5.2	87.4 ± 5.4	87.5 ± 5.6	87.3 ± 7.2
NCON	82.4 ± 5.9	86.2 ± 4.3	86.6 ± 4.2	87.0 ± 4.6	83.8 ± 5.1	85.7 ± 5.4	85.2 ± 5.4	85.7 ± 5.4
	0.69; ±0.42 Very likely↑	*0.59; ±0.43 Likely↑*	*0.50; ±0.31 Likely↑*	*0.28; ±0.23 Possibly↑*	*0.38; ±0.28 Likely↑*	*0.36; ±0.33 Likely↑*	*0.43; ±0.37 Likely↑*	*0.47; ±0.38 Likely↑*
RPE								
CON	12.8 ± 1.9	14.5 ± 1.9	15.1 ± 1.7	15.7 ± 1.5	13.4 ± 1.7	14.8 ± 1.6	15.6 ± 1.5	16.1 ± 1.5
NCON	12.1 ± 2.1	13.4 ± 1.6	14.3 ± 1.4	14.6 ± 1.4	12.8 ± 1.4	14.1 ± 1.2	14.7 ± 1.1	15.2 ± 1.0
	0.35; ±0.38 Likely ↑	*0.64; ±0.35 Very likely ↑*	*0.53; ±0.37 Likely ↑*	*0.74; ±0.28 Most likely ↑*	*0.41; ±0.43 Likely ↑*	*0.61; ±0.48 Likely ↑*	*0.81; ±0.54 Very likely ↑*	*0.89; ±0.59 Very likely ↑*

Q = quartile, ↑ = increase, ↓ = decrease

FIGURE LEGENDS

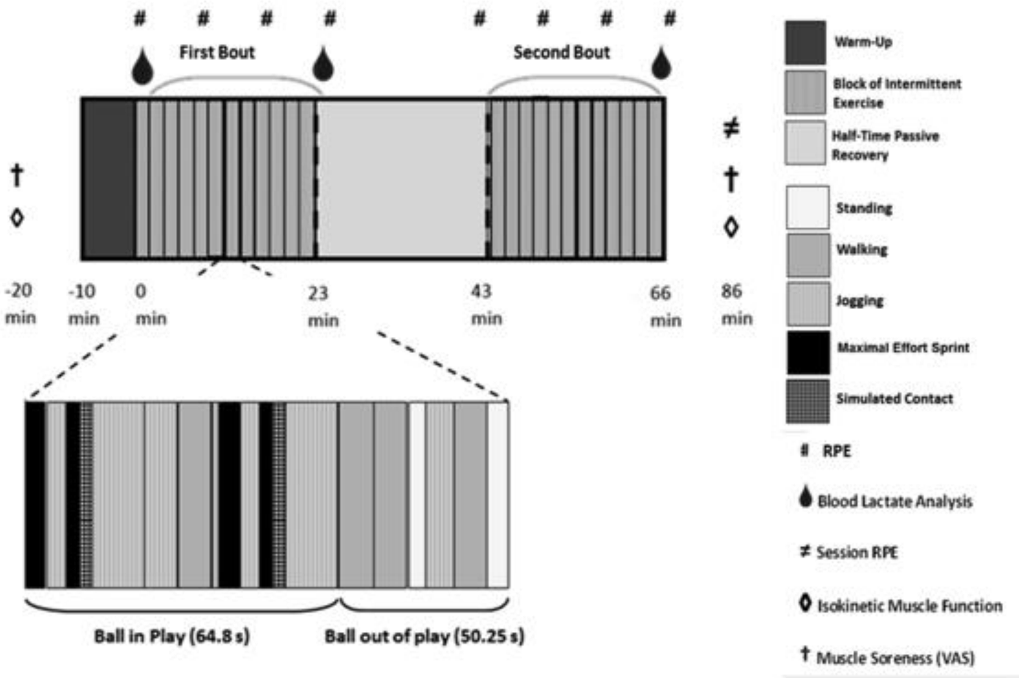

Figure 1. Schematic of the RLMSP-i, including measurements.

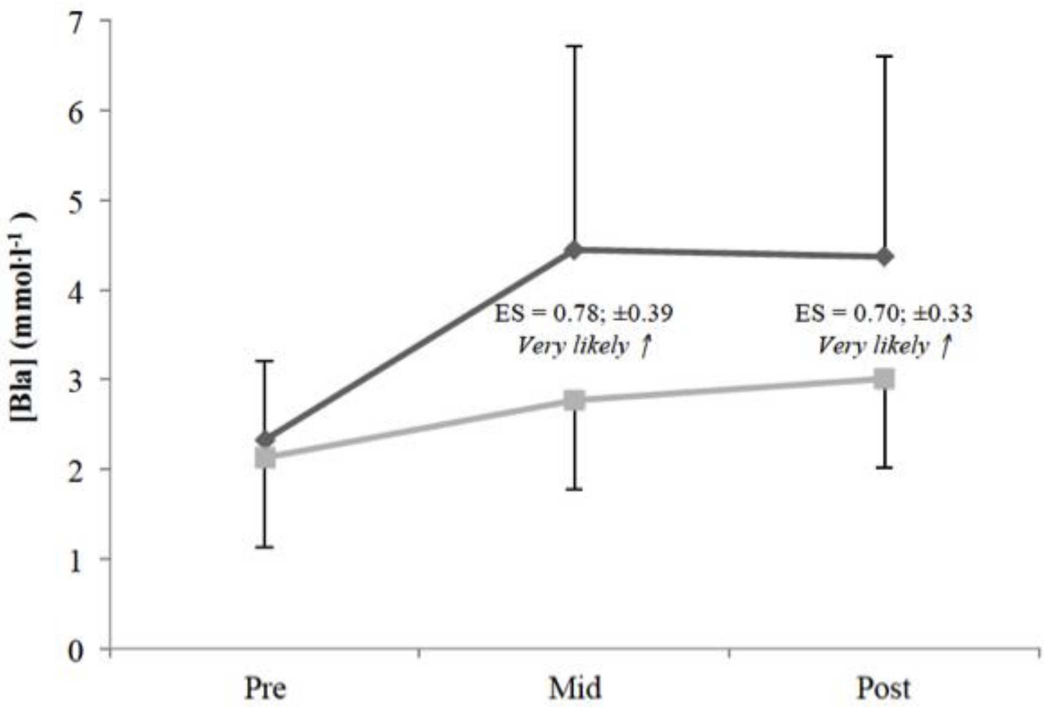

Figure 2. Blood lactate [Bla] (mmol·l^{-1}) pre, mid and post the RLMSP-i with (Black line with diamonds; CON) and without (Grey line with squares; NCON) contact. Values are mean ± SD with ES; ±90% CI and qualitative descriptor between trials included.