Systematic Reductions in Differential Ratings of Perceived Exertion Across a 2-Week Repeated-Sprint-Training Intervention That Improved Soccer Players' High-Speed-Running Abilities

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Abstract

Purpose: To quantify changes in differential ratings of perceived exertion (dRPE) across a two-week repeated-sprint training (RST) intervention that improved high-intensity intermittent running ability and linear speed of semi-professional soccer players.

Methods: Thirteen players completed 3 (sessions 1–3) or 4 (sessions 4–6) sets of 7 sprints (Group 1 [*n* = 7 players]: 30-m straight; group 2 [*n* = 6 players]: 2 × 10-m shuttle), with 20 seconds and 4 minutes recovery between sprints and sets, respectively. Post-set perceptions of breathlessness (RPE-B) and leg muscle exertion (RPE-L) were rated using the CR100® scale.

Results: Overall, RPE-B (mean ± SD: 46 ± 13 arbitrary units [AU], '~hard') was most likely higher than RPE-L (39 ± 13, '~somewhat hard'. Mean difference: 8 AU; 90% confidence limits [CL]: ±2). Set-to-set increases in dRPE (AU; 90% CL: ±~2) were large in session 1 (RPE-B: 15, RPE-L: 14), moderate in sessions 2–5 (RPE-B: 7–10, RPE-L, 7–8), and small (RPE-B: 6) to moderate (RPE-L: 7) in session 6. Across the intervention, RPE-B reduced moderately in Set 3 (-13; ±4) and 4 (-12; ±12), and RPE-L reduced by a small magnitude in Set 3 (-5; ±6). The Set 4 change in RPE-L was unclear (-11; ±13).

Conclusions: We observed systematic intra- and inter-session changes in dRPE across a two-week RST intervention, with a fixed prescription of external load, that improved semi-professional soccer player's high-speed running abilities. These findings could support dRPE as measures of internal load and highlight a usefulness in evaluating RST dose–response.

Keywords: RPE, sensitivity, athlete monitoring, training load, exercise progression.

Introduction

Quantifying the extent to which athletes are responding to a training session, intervention or programme is an integral part of monitoring and management strategies in sport.[1,2] Changes in training outcomes, such as aerobic capacity, strength, speed and power, are of very little value without precise, thorough, and in-depth information about the exercise training itself.[3] This includes both physical performance (i.e., external load) and the associated biochemical (physiological and psychological) and biomechanical responses (i.e., internal load).[4,5] The relationship between internal and external load can therefore provide insights to a player's fitness or fatigue.[6] For example, a reduced internal load in response to a standardized external load may indicate a player is gaining fitness and coping with training.[1] This approach can be useful to evaluate training and prescribe subsequent activity, but is often limited due to difficulties in controlling external load under standardized conditions in the applied setting.[1]

Ratings of perceived exertion (RPE) are a commonly used measure of internal load in soccer.[2] This is likely due to strong associations with multiple indicators of internal exercise intensity, reliability, and feasibility.[7] Separating global RPE into its specific central and peripheral mediators (e.g., respiratory and muscular, respectively) can further enhance internal load quantifications[8] and may well be a suitable indirect alternative measurement of physiological and biomechanical loads.[5] Differential RPE (dRPE) represent distinct psychophysiological constructs in team-sport athletes and have demonstrated face, content and construct validity (convergent and discriminant).[8-10] Despite a growing interest in dRPE as measures of internal load,[11] the dose–response sensitivity of perceived respiratory (central) and muscular (peripheral) exertion in relation to external loads and changes in fitness are largely unexplored.

Repeated-sprint training (RST) is a time-efficient, centrally and peripherally demanding exercise modality that is effective at improving speed, power, and high-intensity intermittent running performance in soccer players.[12] While repeated-sprint bouts ($\geq$ 2 sprints with < 60 s recovery) seldom occur in match-play,[13] performing multiple, all-out efforts, over short distances with brief recovery periods can elicit cardiometabolic and neuromuscular adaptations favourable to soccer performance.[13-15] Evaluating dRPE in response to RST, where external load can be controlled, may therefore serve as an ideal exploratory examination of dose–response sensitivity. Accordingly, the objective of our study was to detail changes, if any, in dRPE across a controlled two-week RST intervention that substantially improved high-intensity intermittent running ability and linear speed in a group of semi-professional soccer players.[16]

Methods

Participants

Data from 13 semi-professional, male soccer players ([mean ± SD] age: 24 ± 4 years; stature: 179 ± 6 cm; body mass: 77 ± 8 kg) who were part of a previously published randomised controlled trial[16] were used in our study. An initial sample of 15 players provided informed consent to participate in the RST intervention.[16] However, two players were excluded from the current analysis due to insufficient attendance (2–3 out of 6 training sessions). Players were part of two different squads, which competed in the eighth and ninth tier of the English Football League System. This study took part at the end of the competitive season and the RST interventions were included as total replacement of training.[16] No matches took place during this period. All players received medical clearance and provided informed consent to participate. The study received ethical approval via an institutional ethics committee.[16]

Experimental Design

The RST intervention was a quasi-experimental, controlled, pre–post parallel groups design in which players were allocated (via minimization) to either a straight-line (STR n = 7) or change of direction (CoD; n = 6) training group. Players from both squads had prior experience of RST as part of their usual training. However, this was the first instance in which a formal RST intervention was used as total replacement of training. A range of fitness tests assessing high-intensity intermittent running ability, speed, change of direction performance and lower-limb explosive power were conducted before and after the six-session programme.[16] Group mean fitness changes from the original sample of 15 players were moderate to large for the Yo-Yo Intermittent Recovery Test Level 1 (YYIRTL1, 28%; 90% confidence limits [CL]: ±4), and large for 5- (-9.5%; ±1.7), 10- (-6.7%; ±1.2), and 20-m (-3.8%; ±0.8) linear sprint times, with no clear difference between groups. No clear changes were observed in Illinois agility test performance (0.7%; ±1.4) or countermovement jump height (1.6%; ±2.7).

The six training sessions took place across a two-week period, which allowed for one session every 2–3 days. This time was chosen to ensure adequate recovery between sessions and to examine the proposed time-efficient nature of RST. Training sessions were performed outdoors on a grass soccer pitch at the same time of day for each team (19:00) to minimise any potential influence of diurnal or circadian variation on the internal response to exercise. We also asked players to avoid any additional vigorous exercise, mentally demanding tasks and foods or beverages containing stimulants (e.g., caffeine) in the 24-hours immediately prior to each training session, due to the putative effects on perceived exertion.

Protocols

All RST sessions were preceded with a 15-minute warm-up. The warm-up consisted of: 5-minutes light jogging, 5-minutes lower-limb dynamic stretching, and 5-minutes activation exercises (jumps, hops, skips, bounds), and three sprint efforts (80%, 90% and 95% of perceived maximum speed). The training programme consisted of 3 (Block 1: sessions 1–3) or 4 (Block 2: sessions 4–6) sets of 7 sprints, with 20 seconds and 4 minutes recovery between sprints and sets, respectively. The STR group completed 30-m efforts and the CoD group completed 2 × 10-m efforts with a 180° turn. These distances were chosen as per RST recommendations[15] and to ensure that effort durations were closely matched between STR and CoD. For the purpose of the present analysis, training data for STR and CoD were pooled so that sample size was not compromised. Players were informed of the two-week programme prior to the start of the intervention period and of sprint distances, sets, repetitions, and rest periods prior to each session.

Outcome Measures

Throughout each session, beat-to-beat heart rate was measured by a chest-worn belt (Polar T31 Coded, Polar Electro Oy, Finland), with data transmitted to a wrist watch (Polar RS400, Polar Electro Oy, Finland) at a rate of 5 kHz. Upon post-session download, raw data were aggregated into 5-second intervals by the proprietary software (Polar ProTrainer 5, Polar Electro, Kempele, Finland). Heart rate traces were then visually inspected and sessions with clear irregularities (e.g., substantial trace dropout) were removed from further analysis (n = 3). Subsequently, set average heart rate (HR_{avg}) including between-sprint rest periods, was retained. Data was expressed as a percentage of maximum heart rate, determined as the highest value recorded during both YYIRTL1.

Player's external training activities were monitored using microsensor units containing a 10 Hz global positioning system (GPS) and a 100 Hz triaxial accelerometer with an output range of ± 13 g. (MinimaxX v4.0, Catapult Innovations™, Melbourne, Australia). Microsensor units were harnessed in a tight-fit vest allowing for an anterior–posterior placement between the scapulae. Players wore the same unit throughout the intervention period to mitigate inter-unit error. Devices were activated 15-minutes prior to the start of each training session to enable a suitable connection to the satellite network. Data were retrospectively processed via proprietary software (Sprint v5.1.7, Catapult Innovations), which smoothed raw velocity and accelerometery data using bespoke algorithms (methods not publicly available). Signal quality was visually inspected after each session and we found no instances of inaccuracies.

Since the RST programme required players to run the same distance at the same intensity for each sprint, traditional locomotor metrics (e.g., total and high-speed running distances), were not considered as reflective external measures. Instead, peak running speed ($km \cdot h^{-1}$) and total PlayerLoad™ (PL, arbitrary units [AU])[17] for each set of 7 sprints were extracted for analysis. Ten hertz MinimaxX GPS have demonstrated good criterion validity (versus laser: mean bias = ~3%, coefficient of variation [CV] = 3–6%, r = 0.98) and high interunit reliability (CV = 4–6%, r = 0.89–0.98) for measuring instantaneous velocity and peak speed during short, straight-line sprint and shuttle efforts.[18] The inter- and intra-unit reliability of PL has been reported as ~1%.[19]

Differential RPE

One week prior to data collection, players were given instruction on the definition of perceived exertion and its scaling,[20] including the importance of separating RPE from other exercise related sensations such as pain, discomfort and fatigue. Instruction was also given on how to appraise dRPE, such that RPE-B depends mainly on breathing rate and/or heart effort, and RPE-L depends mainly on the strain and exertion in the leg muscles (thighs, glutes, calves, etc.). When players arrived for baseline fitness testing, above instructions were verbally reiterated and any questions were answered through discussion. This session was also used to familiarise players with data collection, using post-warm-up and post-test periods to provide ratings across different intensities of exercise (i.e. anchoring).

During RST, players used 7" Android tablets (Iconia One 7 B1-750, Taipei, Taiwan: Acer Inc.) to independently record RPE-B and RPE-L via a numerically blinded CR100® scale, hosted on a bespoke application.[10] Tablets were circulated approximately one minute after each set of sprints. Players were instructed that their ratings should reflect the perceptions of effort experienced for the preceding set only (i.e. for the last seven sprints). Using four tablets in rotation, dRPE were typically collected within a 2-minute post-set period.

Statistical Analysis

Visual inspection of raw data via histograms and Q–Q plots showed approximate normal distribution for dRPE, HR_{avg}, peak running speed and PL in each set. Descriptive summary statistics are therefore presented as the mean ± standard deviation (SD). Our design located units of analysis (outcome measures for a set) nested in clusters of units (players). Since use of the CR100® scale allows RPE to be treat as continuous ratio data, we used separate 2-level linear mixed effect models (SPSS version 24, IBM, Armonk, NY, US) to examine the changes in each outcome measure within a session (set-to-set) and across the two-week intervention (between-sessions). Fixed effects (modelled without a fixed intercept) were set and session number, which were specified as continuous covariates (to determine the linearized change between sets and across sessions) and factors (to determine these changes on a per-session or per-set basis). Slope values for set were evaluated as the change in each outcome measure associated with performing one set of seven sprints. Session was rescaled when entered as a covariate (ranging from 0 to 1) so that slope values represented the linearized change in outcome measures across the entire two-week programme (i.e. the effects of 6 sessions). Models were fit with a random intercept for athlete and a random slope for set or session, using an unstructured covariance matrix, to account for individual differences in the linearized changes.

Uncertainty in outcome measures and ranges of values compatible with our data and statistical models were expressed as 90% CL.[21] We then used non-clinical magnitude-based decisions[22,23] to provide an interpretation of these ranges in relation to reference thresholds. In the absence of a robust anchor for practically meaningful changes in all our outcome measures, we elected to use a distribution-based approach (i.e. standardization) to determine these thresholds.[24] Standard deviations for the intercept (between-athlete) and residual were pooled and multiplied by thresholds of 0.2, 0.6, 1.2, and 2.0 anchor small, moderate, large, and very large changes, respectively.[23] Subsequently, the chance of a change being substantial or trivial was calculated by converting the t statistic for the effect in relation to the threshold (change – threshold/ standard error of the change) to a continuous probability via the one-tailed t-distribution.[25] Quantitative probabilities were then assigned to the following qualitative probabilistic terms: possibly, 25.0–74.9%; likely, 75.0–94.9%; very likely, 95.0–99.5%; most likely > 99.5%.[22] The effect was declared unclear if the chance of being both substantially positive and negative was ≥ 5%. Each effect and its CL were converted to standardized units (effect sizes) for visualisation.

Results

Descriptive data for each set of repeated sprints across the 6-session RST intervention are presented in Figure 1 and Figure 2. The overall (mean ± SD) set values were 46 ± 13 AU ('hard') for RPE-B, 39 ± 13 AU ('somewhat hard') for RPE-L, 80 ± 6% for HR_{avg}, 24.1 ± 4.4 km·h^{-1} for peak running speed and 31 ± 5 AU for PL. Mean RPE-B was most likely higher than RPE-L (mean difference: 8 AU; 90% CL: ±2). Differential RPE were likely higher for the STR training group (RPE-B: 50 ± 16, RPE-L: 43 ± 16) when compared with the CoD training group (42 ± 15, 35 ± 13. Mean difference: 7 AU; 90% CL: ±9).

****INSERT FIGURE 1 NEAR HERE****

****INSERT FIGURE 2 NEAR HERE****

The change in dRPE, HR_{avg}, peak running speed, and PL per one set of repeated sprints are presented in Figure 3. Set-to-set changes in RPE-B (AU; 90% CL: ±~2) were large in session 1 (15 AU), moderate in sessions 2–5 (7–10 AU), and small in session 6 (6 AU). For RPE-L, set-to-set changes (±~2 AU) were large in session 1 (14 AU) and moderate in sessions 2–6 (7–8 AU). Set-to-set changes in HR_{avg} were small in sessions 1, 3, and 5 (~1.3%; ±~1.0). No substantial set-to-set changes were observed in any other sessions for HR_{avg} (~0.9%; ±~1.0) or in any of the 6 session for peak running speed (~-0.1 km·h^{-1}; ±~0.3) and PL (~0.04 AU; ±~0.58).

****INSERT FIGURE 3 NEAR HERE****

Changes in dRPE, HR_{avg}, peak running speed, and PL across the RST intervention are presented in Figure 4. Breathlessness RPE increased by a small magnitude in Set 1 (6 AU; ±5) and reduced by a moderate magnitude in Sets 3 (-13 AU; ±5) and 4 (-12 AU; ±14). The Set 2 change in RPE-B was unclear (2 AU; ±5). Leg muscle RPE increased by a small magnitude in Set 1 (5 AU; ±5) and 2 (6 AU; ±5), and reduced by a small magnitude in Set 3 (-5 AU; ±5). The Set 4 change in RPE-L was unclear (-11 AU; ±14). Changes in other measures of intensity and load were as follows: PL reduced by a moderate magnitude in Set 4 (-3.5 AU; ±3.4); HR_{avg} and peak running speed reduced by a small magnitude in Sets 2 (-1.3%; ±0.4) and 4 (-1.1 km·h^{-1}; ±1.4), respectively, and; no substantial changes were observed in peak running speed for sets 1 to 3 (-0.1 km·h^{-1}; ±0.6), or in PL during set 3 (-0.9 AU; ±1.4). All other between-session changes were unclear.

****INSERT FIGURE 4 NEAR HERE****

Discussion

There is limited data examining the dose–response relations of dRPE with external load and fitness in team sports. In this exploratory study, we quantified changes in dRPE throughout a 6-session RST intervention with a fixed prescription of external load that improved high-intensity intermittent running ability and linear speed in semi-professional soccer players.[16] Our main finding was the systematic intra- and inter-session changes in RPE-B and RPE-L across the intervention period. Ratings for final sets of sprints reduced across the intervention and within-session changes became less substantial towards the end of the training programme. These findings suggest dRPE to be sensitive to changes in high-intensity running abilities. Our data therefore support dRPE as measures of internal load and highlight a usefulness in evaluating training dose–response during repeated-sprint protocols.

Players in our investigation perceived RST as 'somewhat hard' to 'hard', with RPE-B being most likely higher than RPE-L. These data are in contrast to the expected responses of RST, however, which are usually described as more peripherally demanding and perceived 'hard' to 'very hard'.[14,15] Nonetheless, RST is programmed with disproportionate inter- and intra-set recovery periods so that internal load cumulates with each successive bout.[26] Our data suggest that such an outcome was achieved, as RPE-B and RPE-L increased substantially across successive sets of sprints. These changes might be explained by metabolic and neuromuscular consequences,[26] inclusive of anaerobic energy contribution, glycogen depletion and insufficient phosphocreatine resynthesis, hydrogen ion accumulation, respiratory compensations, and reductions in muscle excitability and excitation-contraction coupling.[15] A substantially higher RPE-B in comparison to RPE-L has also been reported for other forms of 'short' high-intensity interval training (HIT). McEwan and colleagues[27] found comparable differences between dRPE (mean RPE-B: 80–85 AU, mean RPE-L: 71–75 AU) following 12 × 30 s treadmill running intervals at 105% maximum aerobic speed with both externally regulated (30 s) and self-selected recovery periods. Participants who cited the completion of HIT sessions as their objective were also found to have utilised heart and respiration rate when gauging their perceived readiness to commence the next interval.[27]

A novel finding from our data was the reduced magnitude of set-to-set changes in dRPE across the 6 training sessions, despite no meaningful changes in external load or intensity (Figure 3). A further key finding was the small to moderate reduction in dRPE following the third set of sprints (Figure 4). This again occurred despite trivial changes in external load/ intensity throughout the two-week intervention (Figure 4). Since moderate to large improvements in YYIRTL1 and linear speed were evident following completion of the RST intervention,[16] it is possible that these systematic reductions are, in part, due to training-induced cardiometabolic and neuromuscular adaptations. Such a finding could be supportive of a dose–response relationship between dRPE and the factors underpinning high-speed running abilities.[1,4,6] The beneficial effects of RST likely occur in the early part of a programme (e.g. as little as 6 sessions),[16] and may be a consequence of increased resting glycogen and phosphocreatine stores, muscle enzymatic activity and buffering capacity, muscle-fibre type and recruitment, and motor-unit synchronization and firing frequency.[13-15]

Contemporary psychophysiological theory suggests that effort perception is generated via corollary discharge of central motor commands.[28] It could therefore be speculated that cardiometabolic and neuromuscular adaptations to RST likely influence dRPE through reductions in the magnitude of central motor command to the respiratory and skeletal (leg) muscles. Although this efference model suggests that afferent feedback from inputs to the central nervous system—such as pulmonary vagal afferents and skeletal muscle tissue—are not the sensory signal generating perception of effort,[28] fatigue-induced spinal or supraspinal motoneuron inhibition can increase central motor command to maintain performance output during exercise,[20] thereby creating an indirect link between afferent feedback and RPE. Though we did not directly measure training 'performance' (repetition sprint time), very large to near-perfect within-player associations between PL and sprint decrement have previously been reported during CoD_{RST} (r = 0.84–0.99).[17] This suggests that accelerometer load may be a useful surrogate indicator of neuromuscular fatigue during RST. This application is based on the theory that reductions in the force-generating capacity of the lower-limb muscles increases ground contact time and centre of mass displacement during the stance phase of gait,[29] which adds further support to our observed data and conclusions. A limitation of this approach, however, is that the proportion of PL occurring in the straight line phase versus the turn is unknown.[17]

Initial-set dRPE increased by a small magnitude over the 6-session intervention. This could imply regression to the mean as an explanation for changed, rather than any training-induced adaptations. It is also difficult to draw conclusions from between-session changes in dRPE following the fourth set of sprints (performed only in sessions 4, 5 and 6), since there were possibly small to moderate reductions in external load/intensity. Finally, the observed changes in dRPE may have occurred, at least in part, due to psychological mechanisms, such as further familiarisation with RPE scaling (i.e., anchoring effects),[30] changes in teloanticipation or the RPE template,[31] or more positive task affect and self-efficacy towards the end of the intervention.[32] Nonetheless, we found the set-to-set changes in set HR_{avg} to be inconsistently trivial and small. When coupled with the unclear between-session changes in latter set HR_{avg}, this might further question the usefulness of heart rate monitoring (when expressed as an exercise average) for evaluating the response to maximal-effort forms of HIT.[14]

A limitation of our study is the pooling of both RST training groups in the analysis of training data, despite no clear between-group differences in fitness changes.[16] Subgroup analysis or the addition of group as a moderating factor was precluded due to the low sample of players. This is also the reason we did not perform any direct inferential comparison of the changes between

RPE-B and RPE-L, despite this being of a clear interest to the application of dRPE in training monitoring. A larger sample size in future investigations may allow for further comparisons of interest to be made. Furthermore, we did not objectively measure environmental conditions (e.g., wind, heat, ground stiffness), which may affect the perception of effort. It is also important to acknowledge that we implemented RST as a total replacement for normal training. This allowed for a more controlled assessment of the dRPE responses to a fixed external loads and systematic fitness changes, but represents a less ecologically valid situation in the holistic team-sport training schedule. Finally, we attempted to quantify the external load of each training session through peak speed and PL. While our RTS sessions were standardized, these measures may not necessarily capture the entire performance demands of sprint-type training in comparison with other, more complex outcomes (e.g., force–velocity profiling).

Practical implications

The collection of within-session dRPE and subsequent post-session analysis of data might offer a time-efficient means of determining if RST has been implemented as intended, in a comparable manner to all athletes (i.e., fidelity), and if they are *generally* gaining fitness or responding to training. This pragmatic approach can be beneficial in team-sports such as soccer, given the congested fixture schedule and allocation of time to technical–tactical preparation, which limits frequent use of formal 'fitness' tests. Our findings and methodology may also be useful for on-field monitoring of individuals or small groups undertaking RST. For example, 'top-up' sessions for substitute players or those not selected for the weekly competitive fixture, as well as injured players during late-stage return-to-play/train strategies. In both these scenarios, the low number of players lends to on-field collection of dRPE and heuristic decision making, if the usual responses to previous RST sessions are known. For example, this information could be used to regulate training session volume (number of reps or sets) or recovery duration.

Conclusions

Monitoring the responses to training interventions can help identify training-induced adaptations and be useful for athlete management. A reduction of internal load to a standardized external load may indicate that an athlete is gaining fitness. In our current investigation, RPE-B and RPE-L systematically reduced across a two-week RST intervention that improved high-intensity running abilities of semi-professional soccer players, despite limited changes in external training load. Such a finding provides evidence to suggest that RPE-B and RPE-L may be useful to evaluate dose–response during RST.

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Figure Captions

Figure 1: Descriptive data (mean ± standard deviation) for ratings of perceived breathlessness (RPE-B) and ratings of perceived leg muscle exertion (RPE-L) throughout the 6-session repeated-sprint training intervention.

Figure 2: Descriptive data (mean ± standard deviation) for average heart rate (HR_{avg}), PlayerLoad™ (PL), and peak running speed throughout the 6-session repeated-sprint training intervention.

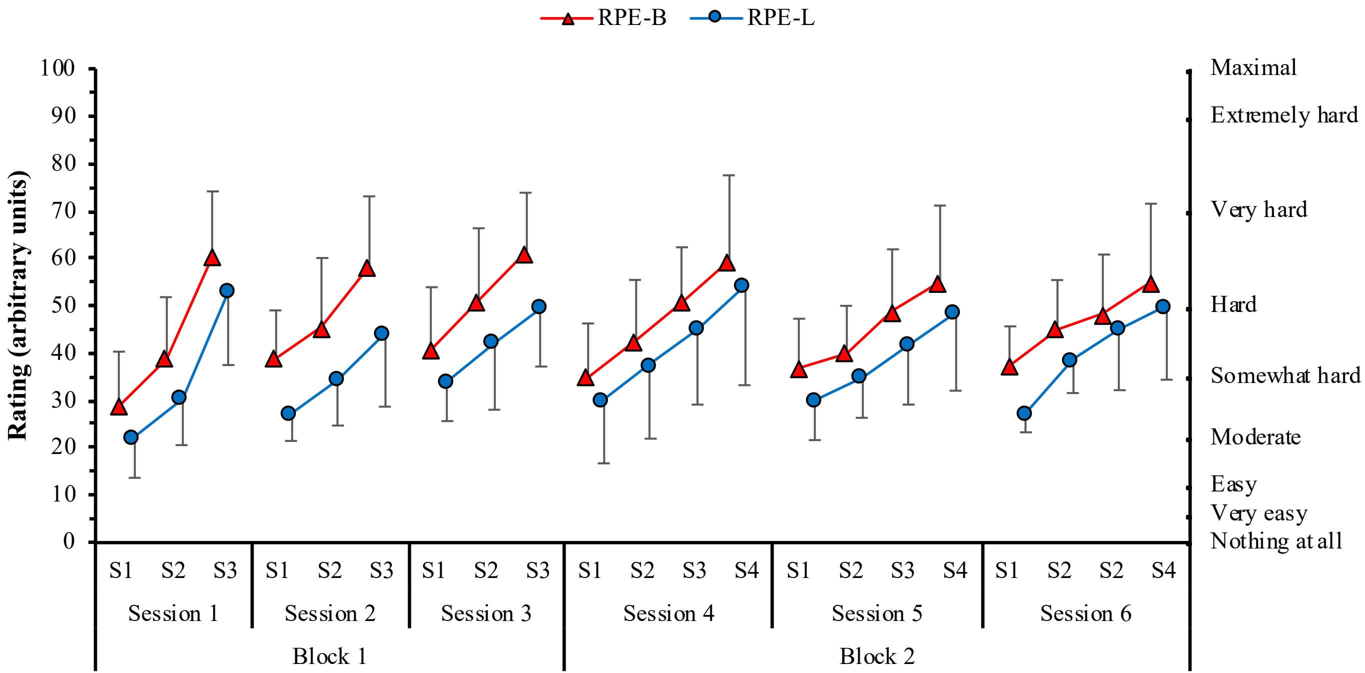
Figure 3: Set-to-set changes in ratings of perceived breathlessness (RPE-B), ratings of perceived leg muscle exertion (RPE-L), average heart rate (HR_{avg}), PlayerLoad™ (PL), and peak running speed throughout the 6-session repeated-sprint training intervention. Data are presented as effect sizes with 90% confidence limits.

[Footnote] Grey shaded area = trivial. Possibly trivial and small effects are presented with the corresponding probabilities (percentage chance) of being trivial (T) and small (S). All other effects are presented with the percent chance of being the observed magnitude (moderate: M, large: L), noted as: *possibly (25.0–74.9%), **likely (75.0–94.9%), ***very likely (95.0–99.5%), and the probability of being trivial, noted as: [a]most unlikely (≤0.5%), [b]very unlikely (5.0–4.9%). Data points without labels were likely to most likely trivial (90.0–99.9%)

Figure 4: Changes in ratings of perceived breathlessness (RPE-B), ratings of perceived leg muscle exertion (RPE-L), average heart rate (HR_{avg}), PlayerLoad™ (PL), and peak running speed across the 6-session repeated-sprint training intervention. Data are presented as effect sizes with 90% confidence limits.

[Footnote] Grey shaded area = trivial. Unclear, trivial and small effects are presented with the probabilities (percentage chance) of being a substantial ↓/ trivial/ substantial ↑. All other effects are presented with the percent chance of being the observed magnitude. For likely substantial effects, the probability of being trivial is noted as: [a]most unlikely (<0.5%), [b]unlikely (5.0–24.9%).

FIGURE 1



RPE-B
RPE-L
Rating (arbitrary units)
100
90
80
70
60
50
40
30
20
10
0
Maximal
Extremely hard
Very hard
Hard
Somewhat hard
Moderate
Easy
Very easy
Nothing at all
S1 S2 S3 S1 S2 S3 S1 S2 S3 S1 S2 S3 S4 S1 S2 S3 S4 S1 S2 S2 S4
Session 1
Session 2
Session 3
Session 4
Session 5
Session 6
Block 1
Block 2

FIGURE 2

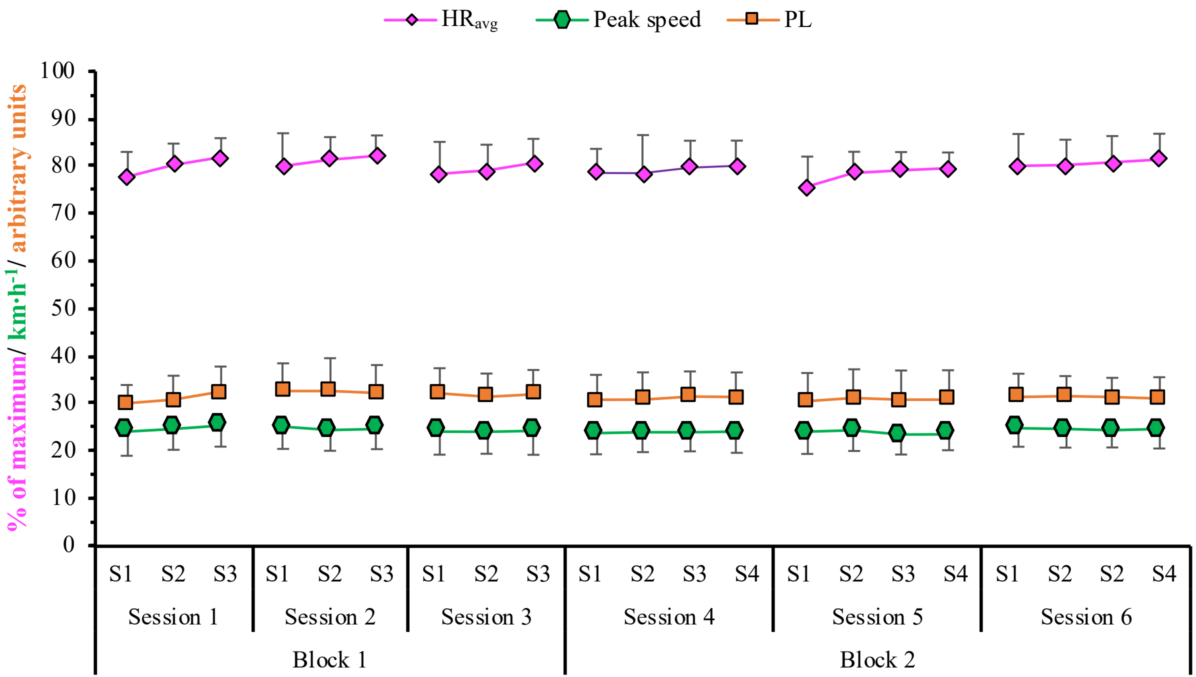
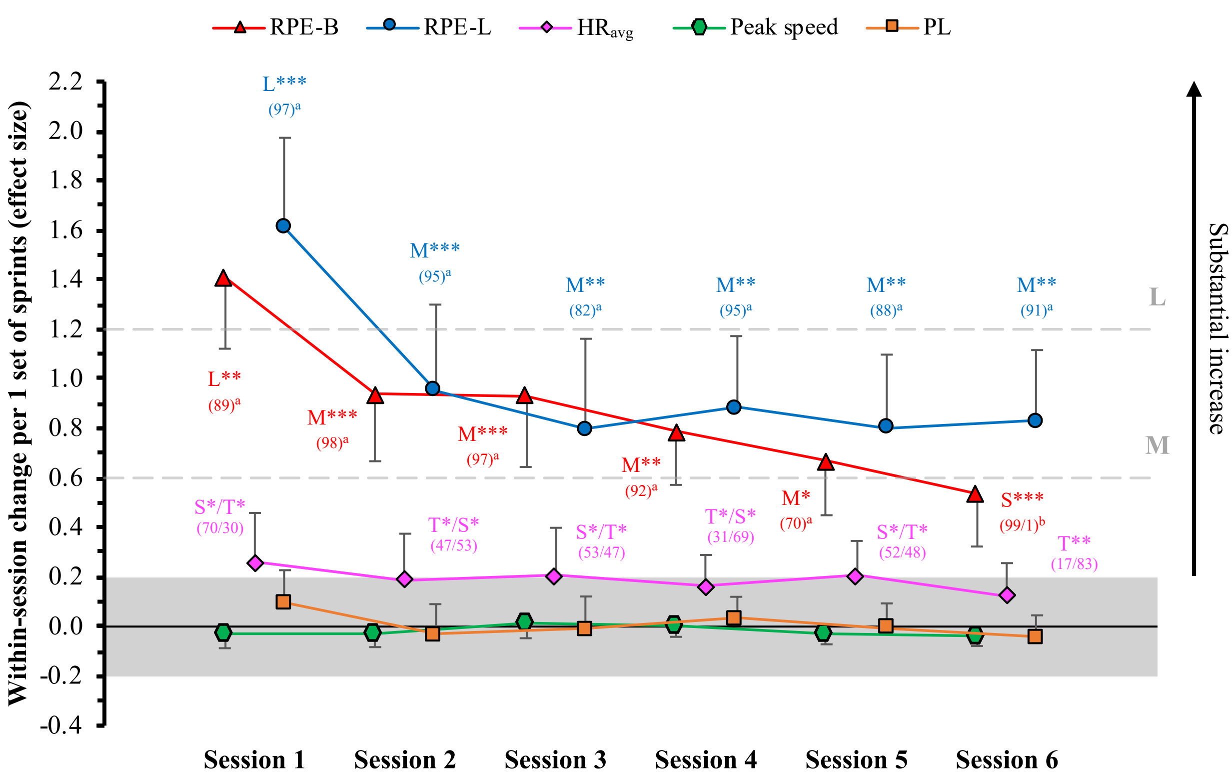
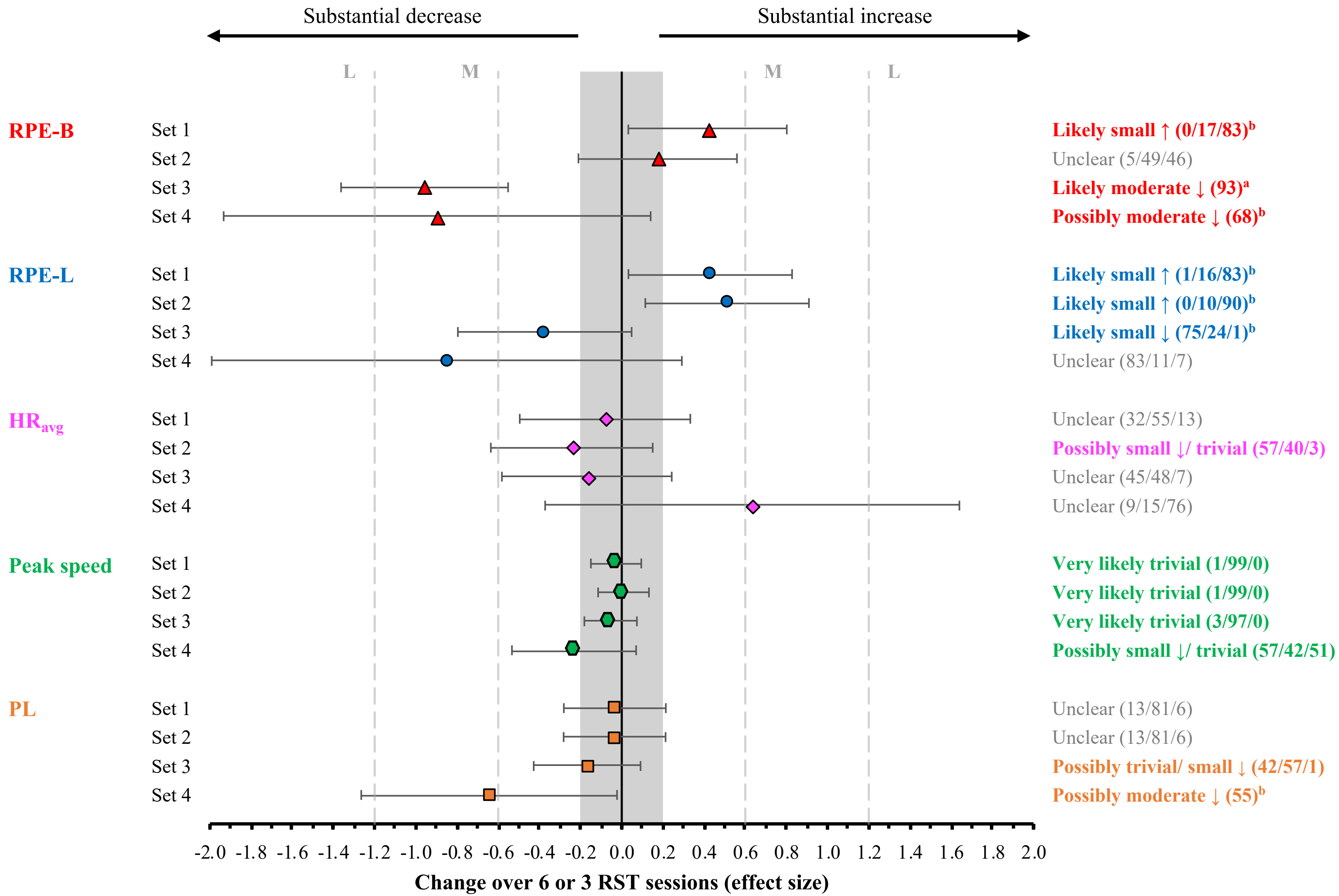

HRavg
Peak speed
PL
% of maximum/ km·h-1/ arbitrary units
100
90
80
70
60
50
40
30
20
10
0
S1 S2 S3 S1 S2 S3 S1 S2 S3 S1 S2 S3 S4 S1 S2 S3 S4 S1 S2 S2 S4
Session 1
Session 2
Session 3
Session 4
Session 5
Session 6
Block 1
Block 2

FIGURE 3



RPE-B
RPE-L
HRavg
Peak speed
PL
Within-session change per 1 set of sprints (effect size)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
L***
(97)a
M***
(95)a
M**
(82)a
M**
(95)a
M**
(88)a
M**
(91)a
L**
(89)a
M***
(98)a
M***
(97)a
M**
(92)a
M*
(70)a
S***
(99/1)b
S*/T*
(70/30)
T*/S*
(47/53)
S*/T*
(53/47)
T*/S*
(31/69)
S*/T*
(52/48)
T**
(17/83)
L
M
Substantial increase
Session 1
Session 2
Session 3
Session 4
Session 5
Session 6

FIGURE 4


Substantial decrease
Substantial increase
L
M
M
L
RPE-B
Set 1
Set 2
Set 3
Set 4
Likely small ↑ (0/17/83)[b]
Unclear (5/49/46)
Likely moderate ↓ (93)[a]
Possibly moderate ↓ (68)[b]
RPE-L
Set 1
Set 2
Set 3
Set 4
Likely small ↑ (1/16/83)[b]
Likely small ↑ (0/10/90)[b]
Likely small ↓ (75/24/1)[b]
Unclear (83/11/7)
HR_{avg}
Set 1
Set 2
Set 3
Set 4
Unclear (32/55/13)
Possibly small ↓/ trivial (57/40/3)
Unclear (45/48/7)
Unclear (9/15/76)
Peak speed
Set 1
Set 2
Set 3
Set 4
Very likely trivial (1/99/0)
Very likely trivial (1/99/0)
Very likely trivial (3/97/0)
Possibly small ↓/ trivial (57/42/51)
PL
Set 1
Set 2
Set 3
Set 4
Unclear (13/81/6)
Unclear (13/81/6)
Possibly trivial/ small ↓ (42/57/1)
Possibly moderate ↓ (55)[b]
-2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
Change over 6 or 3 RST sessions (effect size)