THE COORDINATION VARIABILITY OF 'TRADITIONAL' AND 'SPECIFIC' SPRINT TRAINING EXERCISES COMPARED TO HIGH SPEED RUNNING.

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This study aimed to compare specificity of three different resistance training exercises (Back Squat (BS), Bulgarian Split Squat (BSS), and Single-Leg Romanian Deadlift (SL-RDL) compared to high speed running (HSR). Three-dimensional kinematic data were collected from 6 males (age 22.2 ± 1.6 years, height 1.85 ± 0.05 m, mass 77.55 ± 6.50 kg) who completed two sets of six repetitions with two repetitions in reserve for each resistance training exercise and two 10 second treadmill runs at 20 kph (5.56 m/s). Kinematic results from the hip, knee and ankle (max. flexion, max. extension, and range of motion) revealed there was not an exercise that was consistently similar to HSR. Coordination profiling revealed the BS exercise had similarities to HSR across all three joints, however the BSS did show greater specificity at the hip.

KEYWORDS: sprinting, kinematic, specificity.

INTRODUCTION: The ability to move rapidly provides a competitive advantage in multiple sports (Rimmer & Sleivert, 2000). Resistance training has been broadly accepted as an effective method to improve sprint performance (Delecluse, 1997) when the principles of progressive overload, specificity, and variation (Kraemer et al., 2002) are achieved. Young et al. (2001) grouped resistance training exercises aimed to improve sprint performance from general exercises to very high specific exercises. Little evidence was provided as to why each exercise was assigned to their group, the BS was classed as "general" whereas the BSS and SL-RDL were classed as "medium specificity", furthermore there is a lack of research comparing the kinematics of these resistance exercises to HSR.
Brazil et al. (2020) utilised coordination profiling to assess specificity of exercises in relation to the block start, finding that the 'traditional' BS had greater kinematic similarities to a sprint block start. Mackey and Riemann (2021) found the BSS produced near identical ROM in the ankle and hip compared to the BS, whilst adding requirement of stabilising muscles (Young et a., 2001)**.** When a Romanian deadlift was implemented into a training programme, a non-significant improvement in 30 second sprint performance was found (Karsten et al., 2016), supporting Bolger et al. (2015) who suggest there is no one clear resistance exercise to optimise speed. To improve assessment of an exercise's specificity, coordination and variability of movement patterns provides greater evidence of how movement patterns differ between exercises with the same goal (Romanazzi et al., 2015). The aim of the current study was to identify the kinematics, coordination, and variability of a BS, BSS and SL-RDL compared to HSR.

METHODS: Six male participants (age 22.2 ± 1.6 years, height 1.85 ± 0.05 m, mass 77.55 ± 6.50 kg) all with previous resistance training experience consented to complete the study, following ethical approval. Retroreflective markers were placed bilaterally on the: sternum (1), iliac crest (2), greater trochanter (3), Anterior Superior Iliac Spine (4), Posterior Superior Iliac Spine (5) thigh cluster (6), lateral and medial epicondyle of the femur (7), shank cluster (8), lateral and medial malleolus (9), the first, second and fifth metatarsal heads (10,11, 12), the distal phalange of the hallux (13), and the posterior calcaneus (14) (see Figure 1).

Participants completed two sets of six repetitions for each exercise. Load was determined using Repetitions in Reserve (RIR) with the aim of having two RIR upon completion of a set. HSR trials were completed on a motorised treadmill (H/P Cosmos, Germany), at 20 km/h for 10 seconds. Data was collected for all six repetitions, and both sets of the resistance exercises, as well as the full 10 seconds of the HSR All trials were performed in a randomised order on the same day.

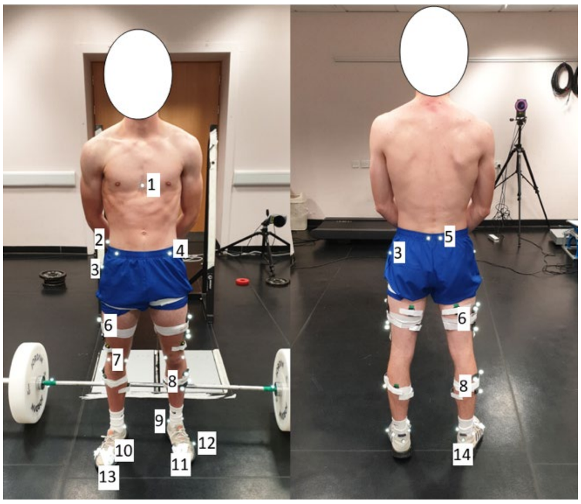

Figure 1. *Retroreflective marker placement.*

Kinematic data were collected at 250 Hz using 16 optoelectronic cameras (Oqus 310+, Qualisys, Sweden). Joint centre positions of the hip, knee, and ankle were estimated using surface markers and used to calculate sagittal plane joint angles. Peak extension, flexion, and Range of Motion (ROM) were calculated for each joint from the participants' dominant leg for three random repetitions of each resistance training exercises, and three random gait cycles from initial contact to toe-off from both 10 second HSR trials. To determine intra-limb coordination data was time normalised to 101 points and coupling angles (Sparrow et al., 1987) of the hip-knee, knee-ankle, and hip-ankle joints was calculated at each of the normalised time points. Repeated measures ANOVA or Friedman tests were used, with a Bonferroni or Wilcoxon signed-rank post-hoc test to compare between the resistance training exercises and HSR biomechanics.

RESULTS: Mean (±SD) kinematic data can be seen in Table 1. The SL-RDL had similar knee flexion, extension, and ROM (°) to HSR (P>0.05), whilst the BS and BSS showed similar kinematics at the ankle joint, but only ankle flexion was not significantly different to that of HSR (P>0.05).

Table 1. *Mean ± SD joint angles and ROM during resistance exercises and HSR.*

Variable	Back squat	Bulgarian split squat	Single-leg Romanian deadlift	High Speed Running
Max Knee Ext (°)	171 ± 5	158 ± 9	167 ± 7	159 ± 6
Max Knee Flex (°)	77 ± 7	88 ± 4	146 ± 13	136 ± 7
Knee ROM (°)	94 ± 8*	70 ± 9*	21 ± 15	23 ± 6
Max Ankle Ext (°)	104 ± 4*	108 ± 3*	100 ± 3*	124 ± 8
Max Ankle Flex (°)	73 ± 5	85 ± 6	92 ± 4	79 ± 6
Ankle ROM (°)	30 ± 4*	23 ± 6*	8 ± 5*	45 ± 6
Max Hip Ext (°)	142 ± 4	118 ± 8	140 ± 6	157 ± 6
Max Hip Flex (°)	53 ± 7*	59 ± 7*	57 ± 10*	119 ± 5
Hip ROM (°)	90 ± 10*	59 ± 9	83 ± 12*	37 ± 7

** = significantly different to HSR (P<0.05).*

Coordination results are shown in Figure 2. The BS and BSS had similar coupling angle profiles to HSR, during the first 40% of the movements. The SL-RDL coordination pattern was not as clear due to greater variation. Compared to HSR, the BS and BSS similarities were through in-phase flexion across all three joint couples, for approximately the first 40% of the movements.

The SL-RDL was most similar to the final stage of HSR, as 80-100% of the movements went from in-phase extension to in-phase flexion. However, during the final 20% of BS and BSS movements, joints were performing in-phase extension.

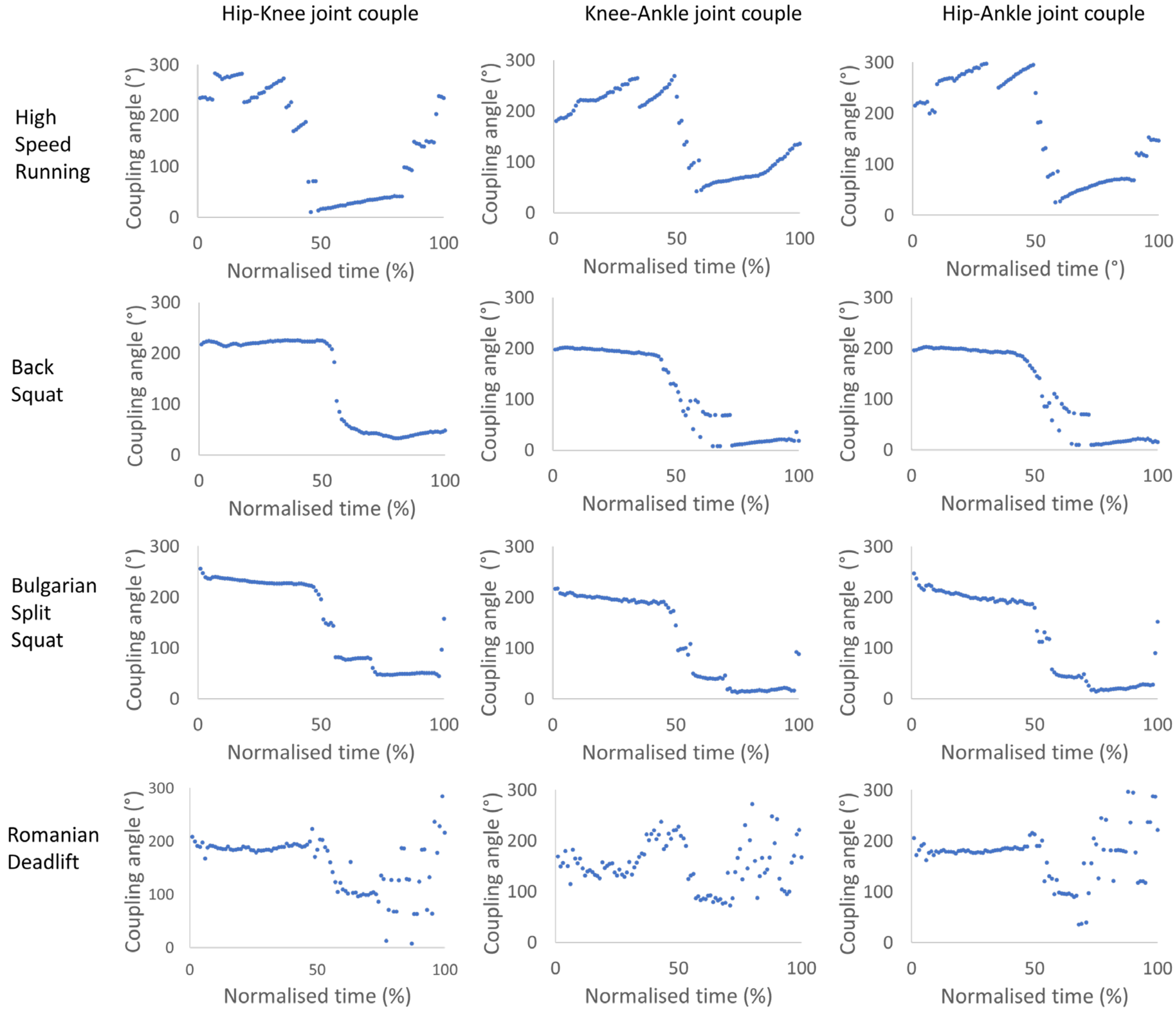

Figure 2. *Coordination patterns of the different exercises at the three joint couples.*

DISCUSSION: The aim of the study was to investigate the specificity of 'traditional' and 'specific' resistance training exercises compared to HSR. The findings revealed various kinematic similarities to that of HSR at the hip, knee, and ankle. Coordination profiles showed in-phase flexion for the first 40% of the BS, BSS, and HSR, whereas the SL-RDL had greater variation and was not similar to that of HSR. The BS showed the most similarities to HSR supporting the findings of Brazil et al. (2020), where coordination profiling highlighted the first 40% of the BS was like a sprint block start showing proximal extension and anti-phase coordination patterns. The largest ankle ROM was found to occur during the BS (30 ± 4°), yet this was significantly smaller ($P<0.05$) than HSR (45 ± 6°), suggesting the BS specificity does not meet the demands of HSR at the ankle joint.

Hip flexion during HSR was found to be similar to previous research (Churchill et al., 2015), but the only resistance exercise to not show significantly larger hip ROM was the BSS, showing the BSS could help train sprinters as excessive hip flexion can be detrimental to sprint performance (Struzik et al., 2016). The SL-RDL produced knee angles that were not significantly different to HSR knee kinematics, yet the coordination profiles of the SL-RDL showed little similarities, reducing the specificity of the SL-RDL. Similarities in coordination across all three joint couples were found in the BS compared to HSR, interestingly the BSS showed the most similarity at the hip-knee joint couple. The BSS showed some distal flexion and then in-phase flexion at the hip-knee joint couple for approximately the first 50% of the movement, like HSR where a mixture of in-phase flexion and distal flexion was seen during the first 40% of the movement. Unlike the BSS, the BS only showed in-phase flexion for approximately the first 50% of the movement. The greater similarity seen by the BSS could be due to its starting position being like the initial contact position during HSR (Orendurff et al., 2018). The HSR coordination data was similar to Gittoes and Wilson (2010) where more out of phase movement occurred during initial contact compared to toe-off, this is particularly seen at the hip-knee and hip-ankle joint couples in the current study. The SL-RDL produced the greatest variation across the measured variables, likely due to lack of familiarity (Myer et al., 2014). This study provides insight into coordination across training exercises compared to HSR and could be used to inform training prescription.

CONCLUSION: Kinematic analysis revealed similarities between all three exercises and HSR at the hip, knee, and ankle joints, however there was not one whole movement that stood out as most similar to HSR. Despite the SL-RDL having knee kinematics most like that of maximum HSR, its coordination patterns varied the most from HSR. The BS and BSS showed similarities to HSR, with the BSS being the most similar due to having distal flexion and in-phase flexion at the hip-knee joint during the initial 40% of the movement – just like that seen in HSR. Future research should look to assess both specificity and overload, through analysis of muscle activity and kinetics in order to improve training prescription.

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