COMPARISON OF JOINT KINEMATICS BETWEEN DIFFERENT RESISTED SPRINT LOADS WITH DIFFERENT PHASES OF ACCELERATION OF NORMAL SPRINTS IN EXPERIENCED SPRINTERS

Roland van den Tillaar[1]

Department for Sports Science and Physical Education, Nord University, Levanger, Norway[1]

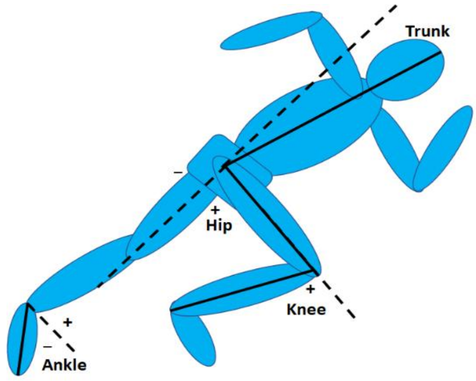
The purpose of this study was to compare joint kinematics of different active resisted loads upon different phases of the acceleration (similar velocity) of a normal sprint. Fifteen experienced male sprinters performed a 50-m sprint with maximal effort from a start block, followed by a 10, 20, 30m with resisted sprints provided by a robotic pully system that gave resp. 65, 50, 25 and 10% reduction of peak velocity, while joint kinematics were measured. The main findings were that in the contact phase most kinematics were similar between the two. During the flight phase maximal hip and knee flexion and velocity were significantly higher in the resisted sprints compared with normal sprint, especially with high resisted loads. It was concluded that most joint kinematics of different active resisted loads are comparable with the different phases of the acceleration of a normal sprint.

KEYWORDS: resistance, angles, segmental angular velocity.

INTRODUCTION: Sprinting performance is in many sports very important, especially acceleration. There are many ways to train to enhance sprint performance. One of these training methods is resisted sprints with different loads. The question often arises what load has to be used to give an extra stimulus for enhancing normal sprint performance, without changing sprint technique too much. Earlier studies on resisted sprints have mainly focused upon the effect of loads upon sprint kinematics like step length, frequency, contact and flight times (Spinks et al., 2007; van den Tillaar & Gamble, 2018). Not many studies have investigated the acute effect of the resisted sprints upon joint kinematics that occur. Cronin et al. (2008) and (Alcaraz et al., 2008) compared joint kinematics when sprinting with different devices (sled, parachute, weight vest) and found differences in joint kinematics when using these two forms of resisted loads. However, none of the studies has compared joint kinematics when sprinting with different loads with the joint kinematics with normal sprints at similar velocities. The different resisted loads could mimic different phases off acceleration of a sprint and thereby in training accentuate that part to enhance performance specific for that phase of acceleration. However, it is not known if joint kinematics are comparable between the different resisted sprint loads with the different parts of acceleration in normal sprint at similar velocity. By the principle of specificity, it is to expect that training with similar joint kinematics (coordination) at similar velocities would have a better transfer from training to competition. Therefore, the aim of the study was to compare the joint kinematics of different active resisted loads upon different phases of the acceleration (similar velocity) of a normal sprint.

METHODS: Fifteen experienced male sprinters (age 27 ± 6 years, body mass 76.6 ± 8.8 kg, body height 1.80 ± 0.07 m) with best 100m times of 10.81 ± 0.45 s performed three sessions: two familiarisation sessions to establish the different decreases in velocities (10, 25, 50 and 65%) by sprinting with active resistance provided by a robotic pulley system (dynaSpeed, Ergotest Technology AS, Stathelle, Norway) and one test session with at least two days between each session. After an individualized warm-up, each participant performed a 50-m sprint with maximal effort from a start block, wearing spikes, followed by a 10, 20, 30m resisted sprints with an active resistance that caused a resp. 65, 50, 25 and 10% reduction of peak velocity in randomised order with 5-6 min rest between each sprint. Each participant put on the Xsens lycra suit (Xsens Technologies B.V. Enschede, the Netherlands), which consisted of 17 IMUs (240 Hz) attached to the athletes' spikes, shanks, thighs, pelvis, sternum, head, upper arms, forearms. minimal and maximal joint angles (ankle, knee, hip and trunk, Figure 1) and angular segmental velocities (foot, lower and upper leg, and pelvis) in sagittal plane and at touch down and toe off for each step with the right limb at each sprint was identified together with the velocity of center of mass at each of these steps by visual inspection and software (MVN Analyze 2021.1, Xsens, Netherlands) and used for further analysis. The average maximal velocity (4-5 steps) starting at when maximal velocity was reached at each of the resisted sprints was calculated and compared with the velocity of the step in the normal sprint that was comparable. The joint kinematics of these steps were compared with each other by a 2 (running condition: normal vs. resisted) x 4 (step: 1-4) ANOVA with repeated measurements was performed to investigate the similarities and differences in joint kinematics between the normal and resisted sprints.

Figure 1: Definition of joint angles of trunk, hip, knee and ankle.



RESULTS: The 65, 50, 25 and 10% reduction of maximal velocity resistances corresponded in general for most athletes with the first four steps of the right foot of the normal sprint, only a significant lower average velocity was found when resisted with 50% reduction velocity pulling force (Fig. 2).

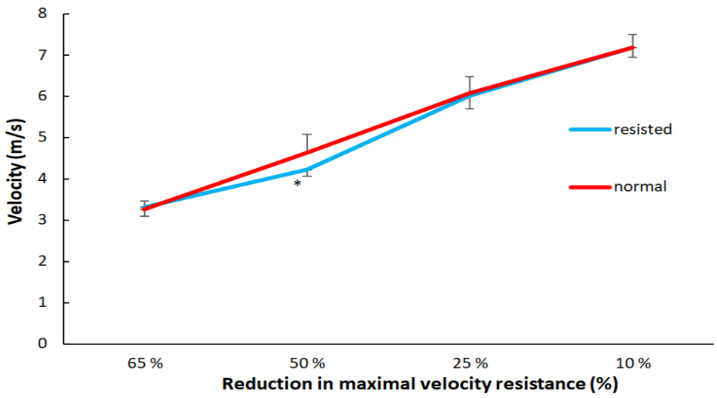


Figure 2: Average maximal velocity with the different resistances and corresponding steps with the normal sprint. * indicates a significant difference between these two conditions (p<0.05).

All joint angles at touch down and toe off ($F \geq 8.5$, $p < 0.001$, $\eta^2 \geq 0.37$), except the ankle angle at toe off load ($F = 0{,}35$, $p = 0.707$, $\eta 2 = 0.03$) were significantly affected by the by the resisted load. However, only a significant effect between the normal and resisted sprints was observed for the pelvis angles and touch down and toe of and for the hip angle at touch down ($F \geq 5.2$, $p \leq 0.039$, $\eta^2 \geq 0.27$). Also, a significant steps*condition interaction effect was found for hip angle at touch down and toe off and for the knee at toe off ($F \geq 4.3$, $p \leq 0.024$, $\eta^2 \geq 0.23$). Post hoc comparison showed that trunk angle was larger on each occasion in the normal sprint compared with the resisted sprints, while hip angle was only smaller at touch down in the 10 and 25% conditions compared with the normal sprint. Furthermore, increased hip angle at toe off later in the normal condition, while it increased earlier in the knee joint at toe off compared with the resisted conditions (Fig. 3).

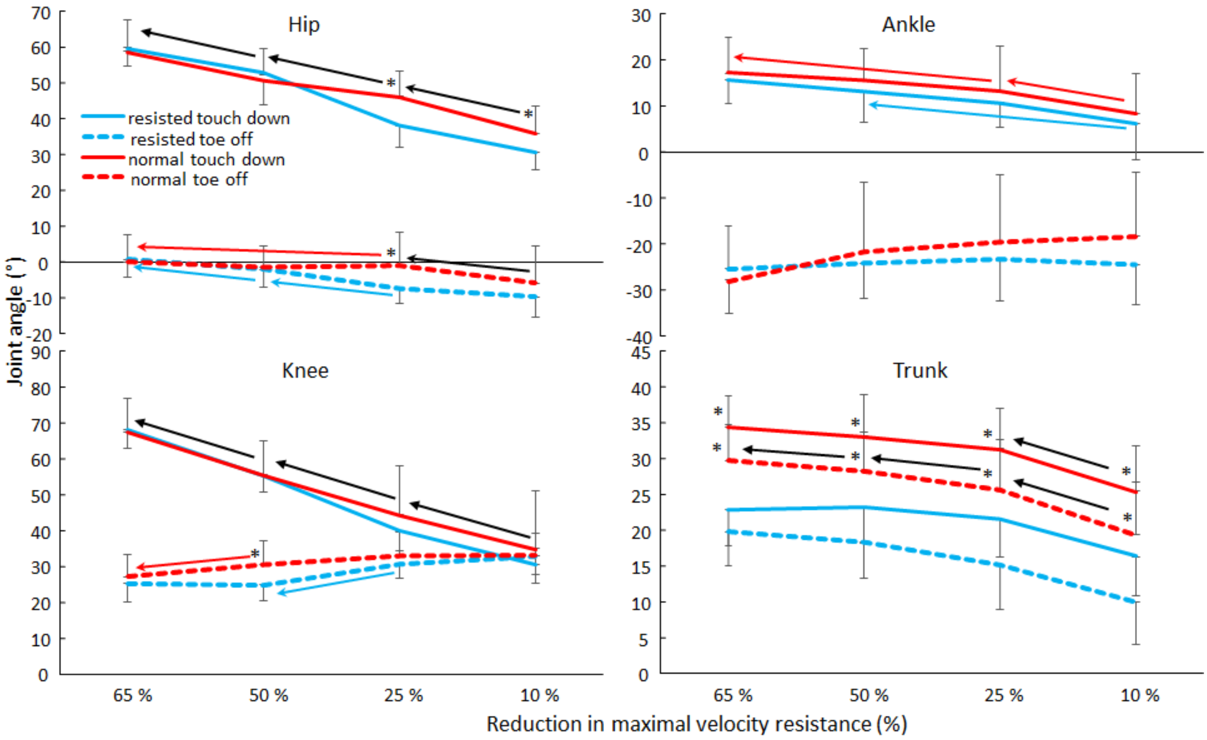


Figure 3: Joint angles at touch down and toe off at the maximal velocity at the different resisted conditions and the normal sprint. * indicates a significant difference between these two conditions (p<0.05). ← indicates a significant difference with all left of the arrow for both conditions, when coloured only for that condition (p<0.05).

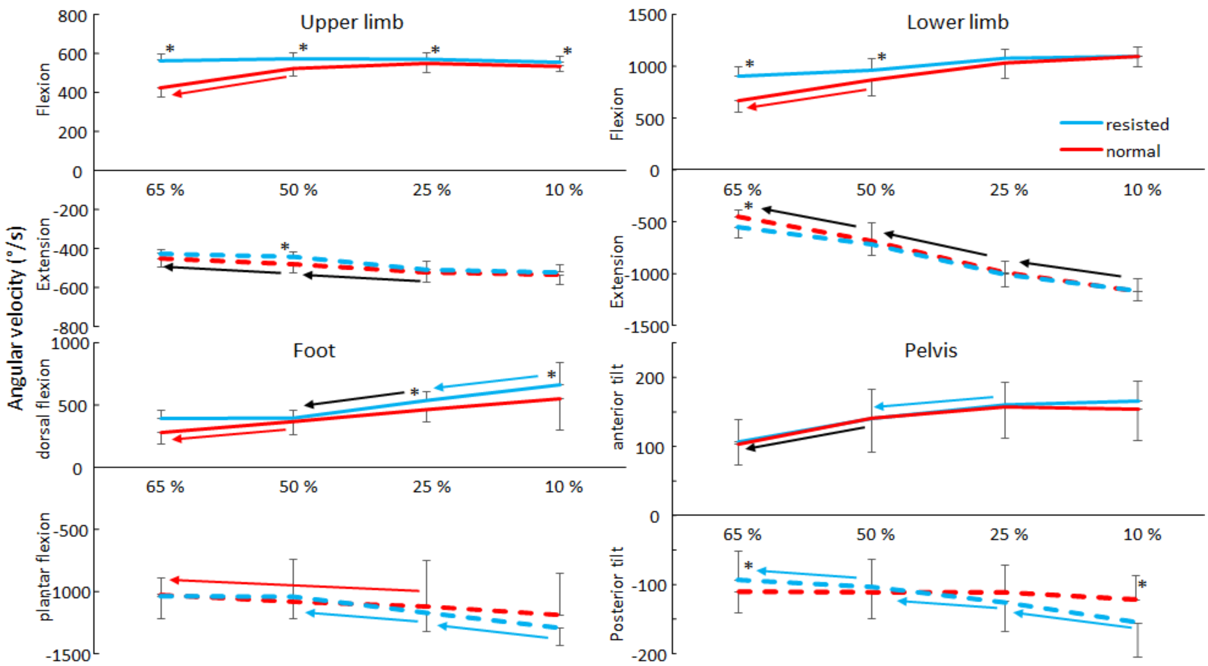


Figure 4: Maximal and minimal angular segment velocities at the maximal velocity of different resisted conditions and the normal sprint. * indicates a significant difference between these two conditions. ← indicates a significant difference with all left of the arrow for both conditions.

All maximal and minimal segmental angular velocities were affected with resisted sprint and between steps in the normal sprint ($F \geq 6.1$, $p<0.001$, $\eta^2 \geq 0.30$). Moreover, maximal upper, lower limb and foot flexion velocities were significantly higher when sprinting with resistance, while the opposite was found for the angular upper limb extension velocity compared with normal sprint ($F \geq 7.1$, $p<0.035$, $\eta^2 \geq 0.55$). Furthermore, a significant interaction effect was found for maximal upper and lower limb flexion ($F \geq 9.9$, $p<0.001$, $\eta^2 \geq 0.63$, Fig. 4).

Maximal and minimal angles were affected with each different resisted sprint and for each step in the normal sprint ($F \geq 4.0$, $p < 0.030$, $\eta^2 \geq 0.22$). However, only the maximal hip and knee angles were significantly higher in the resisted sprints compared with normal sprint ($F \geq 7.6$, $p < 0.033$, $\eta^2 \geq 0.56$). Furthermore, a significant interaction effect was found for all maximal angles in which with higher resistance larger angles were found than in the normal sprint ($F \geq 3.6$, $p \leq 0.040$, $\eta^2 \geq 0.20$, Fig. 5).

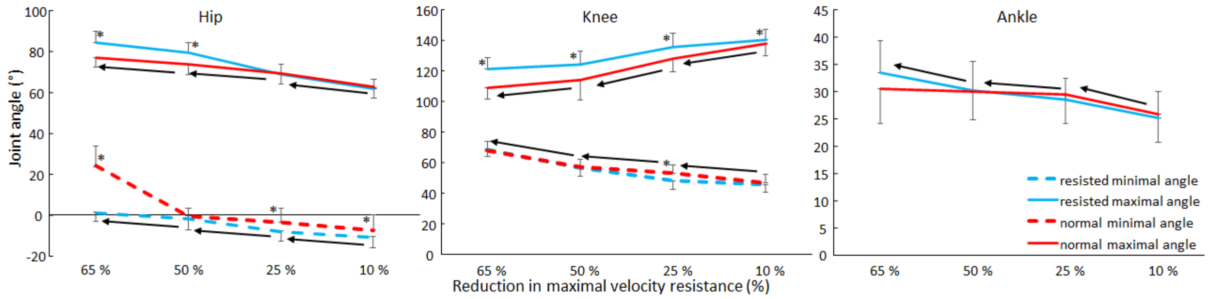


Figure 5: Maximal and minimal joint angles at the maximal velocity at the different resisted conditions and the normal sprint. * indicates a significant difference between these two conditions. ← indicates a significant difference with all left of the arrow for both conditions.

DISCUSSION: in this comparison study the main findings were that at touch down and toe off most angles are similar between the resisted and normal sprints except for the larger trunk angles in the normal sprints and for the hip angle at low resistances, while maximal hip and knee angles were larger in the resisted sprints compared with normal sprint, especially with high resisted load sprint. Moreover, upper, lower limb and foot flexion velocities were higher when sprinting with increasing resisted sprint load.

The trunk angle differences are probably caused by the belt attached around the waist that inhibits the trunk to lean less forward during the resisted sprint (Fig. 3). At touch down and toe off the other angles are not much different between the two conditions, however the maximal angles in hip and knee are larger with increasing resistance compared with the normal sprint, which happens in the flight phase (Fig. 5). Since the angles are larger this resulted in higher angular flexion velocities in these joints to reach these angles. These higher flexion velocities did not result in higher upper and lower limb extension and plantar foot flexion velocities, which are responsible for the propulsion (Fig. 4). Thereby, it seems that propulsion is similar between the two conditions. However, kinetic and electrographic measurements should be performed to confirm this statement about similar propulsion forces and muscle activity.

CONCLUSION: based upon the findings of the study joint kinematics of different active resisted loads most are comparable with the different phases of the acceleration of a normal sprint. Thereby athletes can train with different resisted loads to accentuate the different phases of acceleration of normal sprints. Training studies should be conducted to investigate if training with these different loads enhance the specific parts of the acceleration of a sprint.

REFERENCES

Alcaraz, P. E., Palao, J. M., Elvira, J. L., & Linthorne, N. P. (2008). Effects of three types of resisted sprint training devices on the kinematics of sprinting at maximum velocity. *J Strength Cond Res, 22*(3), 890-897. doi: 10.1519/JSC.0b013e31816611ea

Cronin, J., Hansen, K., Kawamori, N., & McNair, P. (2008). Effects of weighted vests and sled towing on sprint kinematics. *Sports Biomech, 7*(2), 160-172

Spinks, C. D., Murphy, A. J., Spinks, W. L., & Lockie, R. G. (2007). The effects of resisted sprint training on acceleration performance and kinematics in soccer, rugby union and Australian football players. *J Strength Cond Res, 21*(1), 77-85

van den Tillaar, R., & Gamble, P. (2018). Comparison of step-by-step kinematics and muscle activity of resisted, assisted and unloaded 30 m sprint runs in experienced sprinters. *Trans Sports Med, 1*(4), 151-159