Run-up coordination with and without pole carriage: The case of novice pole vaulters.

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The purpose of this study was to determine the influence of pole carrying on the biomechanics of the run-up in the pole vault. Eight novice male pole vaulters participated and performed six 30-m sprints, three with and three without a pole. A tripod mounted digital video camera was horizontally panned to follow the athletes from left to right. The mean velocities, times of stance and swing phases and sagittal plane angles of the hip, knee and ankle joints were recorded. The results indicated that the average velocities during the runs were significantly slower with pole than without. The runs with pole were characterized by significantly less flexion of the hip and knee joints at the instant of maximal hip flexion during the swing phase. An anterior imbalance was created by the pole and this tended to increase the braking phase and decrease the stride length, causing a 'slight precipitation' by the athletes' anticipation of the foot touch-down.

Keywords: Pole Vault Biomechanics, Kinematics, Coordination.

INTRODUCTION

The aim of pole vaulting is to jump over a high cross bar with the help of a long pole. Performance is correlated (r=0.69; Sullivan et al., 1994) with the vaulter’s horizontal velocity at take-off. The horizontal velocity is the product of stride rate and stride length, and the literature on ‘free’ running biomechanics (Novacheck, 1998; Schache et al., 1999) have defined a cycle by two consecutives strides, and a stance phase and a swing phase per cycle for each lower limb. The stance phase contained the braking phase and the push-off phase whereas the swing phase is divided into two parts: the initial swing and the terminal swing. All of these variables are linked with the decrease in horizontal velocity, which can be caused by a restriction of the arm swing (Grant et al., 2003). The aim of this study was thus to identify the transformations in the kinematical variables of running when an athlete is carrying a pole. It was expected that the mean velocity would be affected by an asymmetric coordination between the lower limbs.

METHODS

Eight male students at the Faculty of Sports Science of Rouen, were the subjects of this study (20.4 ±0.92 years, 178.5 ±6.02 cm and 70.4 ±3.58 kg). They had all had introductory classes in pole vaulting as part of their studies, and had a good high-school level in sprint (84.1 ±2.55% of the 60m world record). All the participants carried the pole on their right side.

After warming-up, the subjects performed three run-ups with a pole carriage and three without. The distance over which the participants were timed was 20-m, with a 10-m ‘rolling’ start. A tripod mounted digital video camera (50 Hz, Panasonic®) was placed 10-m from the 2-m marked runway and horizontally panned to follow the athletes from left to right. The digital video camera was connected to a video timer (50 Hz, FOR A®), a video recorder (50 Hz, Panasonic, NV-FS 100 HQ®) and a monitoring screen (Brandt®). This experimental video set-up determined the mean velocity, the mean stride length and rate, and the time of each stance and swing phase.

During the right cycle (pole side) in the middle of the recorded run-up, Dart Trainer® (Dart Fish™, Switzerland) software allowed to obtain the subjects’ kinematics by markers placed on the body: 1) the lateral malleolus of the fibula, 2) the lateral epicondyile of the femur, 3) the antero-superior edge of the iliac ridge, and 4) the base of the neck on the sternocleidomastoid muscle. Paired Student t-tests were used to compare the differences between run-ups without pole and run-ups with pole. For all procedures, significance was accepted at an alpha level of 0.05.
RESULTS & DISCUSSION

The hypothesis appeared to be significant by the video analysis. Indeed, the mean velocity of the run-up with pole was lower (p<0.05) than the mean velocity without pole. This significant difference was reflected by the significant lower mean stride length (p<0.01) when the athlete carried a pole whereas mean stride rate did not show any significant difference (p=0.26). It is in accordance with Grant et al. (2003), stating that running with a two handed carriage significantly slowed the run-up velocity. Moreover, the relative stance phases showed significant differences between the right and left stance phases with pole (p<0.05) and between both right stance phases with and without pole (p<0.01). This indicates the asymmetry pattern of the pole vault run-up by the pole carriage, which limits the rotations of the shoulders (Novacheck, 1998).

Figure 1. Sagittal plane angles of hip (1a.) and knee (1b.) joint as function of the running cycle with a pole (dashed line) and without (solid line); The vertical lines represent the significant difference (p<0.05) of relative time for the braking phase between the run-up with a pole (dashed line) and without (solid line). *: Significant difference of angle (p<0.05).

The video analysis (Figure 1) revealed the longer braking phase when the athlete carried a pole compared with a run-up without pole. The cycle showed that the maximal hip flexion (Figure 1a.) and the maximal knee flexion (Figure 1b.) were lower during the run-up with pole than without. Thus, the loss in horizontal velocity is caused by (a) a longer stance phase with a longer braking phase (Novacheck, 1998) and by (b) a lower stride length linked to the lower maximal hip and knee flexion, whereas the maximal hip extension didn’t show any significant difference between both conditions of run-up (Schache et al., 1998). It seems that this last phenomenon could represent the anterior imbalance created by the length of the pole. Consequently, sprinting and leaping exercises with a pole carriage appear to be extremely relevant for the novice pole vaulters, in order to improve the running cycle gait.

REFERENCES


Performance in pole vaulting corresponds to the height of a cross bar and is highly correlated with the horizontal velocity of the vaulter at take-off. However, the athlete is constrained by the pole carriage, which prevents the arm swing and decreases the running economy and velocity. It was expected that the pole carriage induces a loss in horizontal velocity of 4.5% in elite pole vaulters compared to a ‘free’ run-up. The effects of pole carriage on the running kinematics in novice pole vaulters, had never been studied. The aim of this study was to identify the transformations in the kinematical variables of running when an athlete carrying a pole. It was expected that the mean velocity would be affected by an asymmetric coordination between the lower limbs, particularly due to a longer stance phase.

The mean and final velocities of the run-ups with pole were, respectively, 5.3 and 6.3% lower (p<0.05) than without pole. The mean stride length was significantly lower (p<0.01) when the athlete carried a pole whereas mean stride rate did not show any significant difference (p=0.26). The relative stance phases showed significant differences between the right and left stance phases with pole (p<0.05) and between both right stance phases with and without pole (p<0.01). When the athlete carried a pole, there are significant differences in the running cycle kinematics (on the pole side) between the run-up with and without pole carriage (Figure 2).

The results are in accordance with the literature about running with a two handed carriage which decreases the running velocity. Also, they indicate the asymmetry pattern of the pole vault run-up by the pole carriage, which limits the rotations of the shoulders. Moreover, the loss in velocity, due to pole carriage, is correlated with the level of expertise, i.e. the loss in velocity increases with the decrease of the expertise. There is a loss in horizontal velocity for two reasons: (a) a longer stance phase with a longer braking phase and (b) a lower stride length linked to the lower maximal hip and knee flexion, whereas the maximal hip extension didn’t show any significant difference between both conditions of run-up. Consequently, sprinting and leaping exercises with a pole carriage appear to be extremely relevant for the novice pole vaulters, in order to improve the running cycle. By using a higher recording frequency and several pole-ground angles along the run-ups would be of benefit for further studies. However, this study pointed out the relevant consequences of pole carriage on the run-up kinematics for novice pole vaulters with the usual equipment and could be used to establish a reference in the context of longitudinal training support to follow the improvement of novice athletes.