CORRELATION BETWEEN COORDINATION VARIABILITY AND SPRINT VELOCITY IN DIFFERENT SKILL LEVEL

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The relationship between variability and motor performance may differ among different skill level subjects. The purpose of this study was to identify the relationship between coordination variability and sprint velocity in athletes group and non-athletes group. The continuous relative phase method was used to quantify the coordination variability across trials. The results suggest that the correlation between coordination variability and sprint velocity is different in athletes group and non-athletes group. For Hip-Knee coordination variability of the braking phase, in athletes group, there was a significant negative correlation between variability and sprint velocity, the faster the velocity was, the less variability was. But in the non-athletes group, the correlation was positive, the faster the velocity was, the greater variability was. This study has highlighted the effect of skill level on the relationship between coordination variability and performance.

KEYWORDS: motor performance, continuous relative phase, motor control

INTRODUCTION:

Variability is an important characteristic of human movement. There are two different views about variability. In the view of motor learning, coordination variability will be high in the early stage, and the improvement of motor skills may result in a stable performance with low coordination variability. In this view, high variability may be detrimental to athletic performance. And the higher the skill level, the lower the variability. However, in the view of dynamic systems theory, the benefits of variability were emphasized. It represents the adaptability of the system (Robertson et al.,2013). When variability is high, the system is more flexible and can adapt to more perturbations (Holt et al.,1995). The effects of coordination variability on skill level or performance are complex and may depend on the sports item (Preatoni et al.,2013). Although high variability may represent more flexible and can adapt to more perturbations in a dynamical system, we should probably not assume that increased coordination variability contributes to improved performance in all motor tasks. The effect of variability on performance may also be related to the skill level. The relationship may differ among different skill levels.
Running is one of the most basic movements in human, and gait is controlled by coordination n between multiple joints. To acquire higher sprint performance, it is necessary to undergo long-term training to overcome coordination obstacles between the limbs. Therefore, the purpose of this study was to determine the correlation between coordination variability and sprint velocity in different skill levels.

METHODS:

Thirty-two male college students (sixteen athletes and sixteen non-athletes) participated in this study. The training years of athletes group were 3.1±1.6y, the personal bests in 100m were 11.18±0.25s. There was no training experience in the non-athletes group. Three-dimensional kinematic data were collected using a 16-camera Qualisys motion analysis system sampled at 200Hz during the maximum velocity phase of sprinting. The distance between the starting position of sprint and the start of testing area was about 45m, and the length of the test area was about 15m. Subjects were required to perform their best ability. Valid data were collected

3 times for each subject, and sufficient rest time was guaranteed between each data collection. Twenty-nine retroreflective markers were attached to anatomical landmarks on the subject for use with the Helen Hayes model (Vaughan et al.,1999).
The three-dimensional coordinates were filtered by Butterworth fourth-order low pass with a cutoff frequency of 13Hz. The main gait events, heel-strike (HS) and toe-off (TO) were identified from the vertical position of toe marker. A further event, the minimum knee flexion angle (KFA) was identified from the knee joint angle, the maximum knee joint center height (KJC)was identified from the vertical position of knee joint center. In this research, only the right limb coordination variability were analysed, and the gait cycle was defined as HS to HS. Four main phases were included in the analysis: braking phase from HS to KFA, propulsive phase from KFA to TO, pre-swing from TO to KJC, post-swing from KJC to HS.
The continuous relative phase between two joints was calculated by the method of Robertson et al. (Robertson et al.,2013). Firstly, the joint angle defined as the Cardan angles between two adjacent segments was calculated, angular velocity was then calculated with an appropriate differentiation method. Once the normalization procedures of angle and angular velocity had been accomplished, the next step was to scale them to 100% gait cycle. For each of the joint, the phase angle was calculated at each instant in the cycle by $\emptyset(i) = \tan^{-1}\left[\frac{\omega'(i)}{\theta'(i)}\right]$, where ω' was the normalized angular velocity, and θ' was the normalized angle. The CRP of the two joints was then calculated as $\mathrm{CRP}(i) = \emptyset_a(i) - \emptyset_b(i)$, where $\emptyset_a(i)$ was the phase angle of proximal joint and $\emptyset_b(i)$ was the phase angle of distal joint at data point i in the cycle. The CRP were created for Hip-Knee and Knee-Ankle in this study. The coordination variability was obtained by the standard deviation at each data point across 3 trials.

RESULTS:
Pearson correlation analysis showed that the correlation between Hip-Knee coordination variability of braking phase and sprint velocity was r^2=0.3061 in athletes group(r=-0.553 , p=0.026). In non-athletes group, the correlation was r^2=0.3376(r=0.581, p=0.023). There was no correlation between Knee-Ankle variability and sprint velocity.
The Hip-Knee coordination variability of the braking phase for athletes group was presented in Figure 1 and non-athletes group in Figure 2

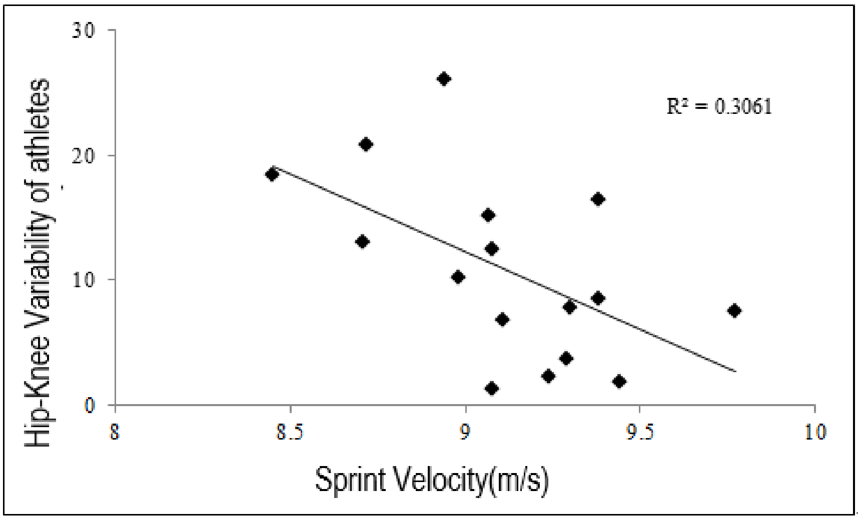

Figure 1: Hip-Knee coordination variability of the braking phase across trials for each subject in the athletes group.

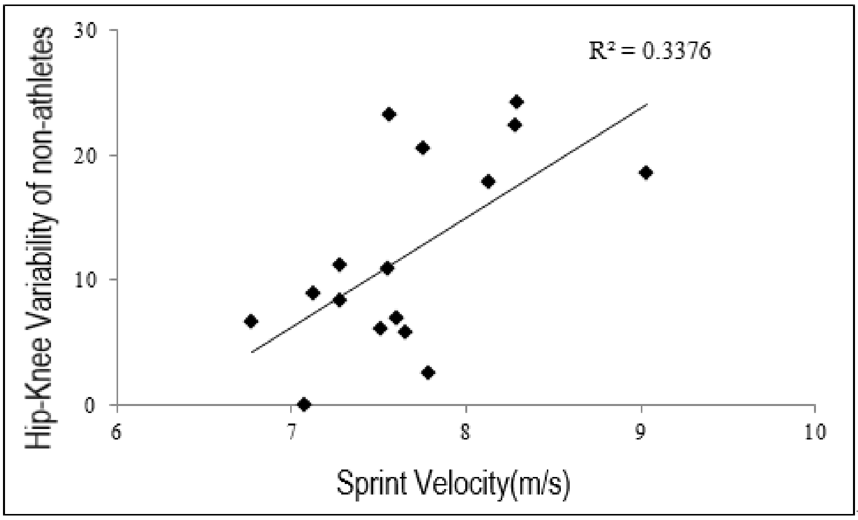

Figure 2: Hip-Knee coordination variability of the braking phase across trials for each subject in the non-athletes group.

For Hip-Knee coordination variability of the braking phase, in athletes group, there was a significant negative correlation between variability and sprint velocity, the faster the velocity was, the less variability was. But in the non-athletes group, the correlation was positive, the faster the velocity was, the greater variability was.

DISCUSSION:

This study aimed to evaluate the correlation between coordination variability and sprint velocity in athletes group and non-athletes group. Results showed that the correlation may be complex with the level of motor skill, for athletes, more stable coordination help achieve higher velocity while more flexible coordination help higher velocity in non-athletes. Variability in motor performance is not only a nuisance but is a ubiquitous and informative biological feature(Sternad,2018). In dynamical systems theory, it has been suggested that coordination variability allows the flexibility to adapt to perturbations (Hamill et al.,2012), the results of this study don't seem to support this hypothesis. The results of Cazzola et al. 's research on race walking are similar to this study (Cazzola et al.,2016). The subjects completed tests on a treadmill, using continuous relative phase to evaluate coordination variability. All subjects were athletes divided into elite, international, and national according to their performance best, and the national group reported higher coordination variability than international and elite, which was similar to the results of athletes in our study. A study evaluated the influence of skill of expert triple jumpers on the coordination variability, five subjects were all athletes, using the vector coding technique (angle-angle) to quantify coordination variability, the results were consistent with a U-shaped curve, representing coordination variability as skill increased (Wilson et al.,2008). This study highlights the need to address the learning effect when analyzing coordination variability from a dynamical systems perspective. From Newell's hierarchy of stages of learning, the non-athletes group of our study may be in the early stages of motor learning, coordination characteristics are being acquired. When muscles can coordinate their movements in more ways, sprint velocity increases. While the athletes group may be on the stage of skill development, after acquiring the appropriate coordination characteristics, the refinement process will lead to more consistent performance. Therefore, the higher the skill level of athletes in this stage, the lower the variability. It was a pity that the skill level of subjects in the athletes group were all national level. According to motor learning theory, elite 100-meter runners may be likely to show decreased coordination variability as velocity increases. In Floría et al. 's study (Floría et al.,2017) continuous relative phase was used to evaluate coordination variability of running, and the results showed that coordination variability of the lower limb had no difference in athletes group and non-athletes group. The results are different from ours. It may be due to the different running speeds, in that study, running speeds are self-paced, and sprinting with the best effort in our study. This also suggests that movement speed may affect the relationship between coordination variability and skill level, and although coordination variability is affected by skill level, coordination variability of different skill levels may be the same at constant speed movement.

CONCLUSION:
For collegiate level 100-meter athletes, the more repeatable and stable the coordination patterns, the better their performance. But for non-athletes, more flexible coordination patterns may help to achieve higher velocity. This study has highlighted the effect of skill level on the relationship between coordination variability and performance.

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