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Biomechanical Analysis of the Influencing Factors on Fitness Running Leg's Stomp Effect

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Abstract: The kinds of exercise increases continuously, so that, people feel kind of overwhelmed; as for its costs and complexity of implementation, running exercise is the best choice. In order to make the running technology get higher and faster development, this study uses biomechanical principles to analyze the factors that affect the running speed in running sports. The study first summarizes the kinematic parameters of running processes, analyzes the pace of a cycle and then conducts the summarization and analysis on the kinematic characteristics of stride frequency and stride length, finally analyzes the starting techniques, swing techniques and stomp techniques. Through the theoretical research and data analysis of the text, it tries to provide stronger theoretical basis for running exercise and provide a suggestive reference for the study of running exercise.

Key words: Step frequency and step length, exercise impulse, peak value, biomechanics

INTRODUCTION

Running is a simple fitness exercise sport; because of its low cost it has audience of more than 95% of the world population. Running process is a typical cyclical movement, is one of the most basic movement in physical activity. With the development of bio-mechanics, computer technology and measurement technology, the study of sports has entered into a more perfect proportion; this study conducts biomechanical research on the basic techniques of the running process, in order to provide a theoretical basis for the development of the sport.

For the studies of running exercise many people have made an effort, it is these people's efforts that makes running more in line with the needs of different spotters, some scholars put forward their own points of view, wherein: Chen (2012) analyzed the physiological structure of hip and the movement patterns and important role of hip movements in the running's motion technology, indicating that the correct movement patterns of the hip help to improve the effectiveness and economics of technology process in running sports; Deng (2011) from the perspective of the biomechanics studied human characteristics of running exercise, the centroid laws of motion and deformational and translational work are just power source for running analysis, explored the relationship between internal forces and external forces, emphasized that quality "the centroid translational motion of many autonomous motion system heart is the result of external forces caused by the system's internal force" (Zhang, 2013); Li Jian-wei studied the motion of people on the treadmill, by high-speed camera of the motion capturing instrument capture the human knee and ankle joints' angle and angular velocity and other data in a gait cycle and conducted chart analysis on the experimental data, finally concluded the negative factors that the body cannot run fast (Tan, 2013).

Based on previous studies, this study analyzes the technical features of pedal phase and flight phase in a motion cycle of running sports, studies the relationship between stride frequency and stride length that are related to running speed, using biomechanical principles to focus on studying starting technique, swing techniques and stomp techniques, by the analysis in the study explores the scientific of running movement and provides a theoretical basis for the running study.

BIOMECHANICAL FACTOR ANALYSIS OF RUNNING

Kinematic parameters of running: The most important kinematic parameters in the running movement is running speed; and running speed depends on the step length and stride frequency; biomechanical factors that affect the running speed have A. air resistance, B. step length and step frequency; factors that impact step length and stride frequency have C. support time and lifting time, D. vacated time and vacated distance; factors that impact the support time and the lifting time have E. foot friction, F. grilled kicking technology; factors that impact the flight time and the vacated distance have G. the lifting speed and H. the lifting angle, the above factors constitutes the structure of S. running speed, as shown in Fig. 1.

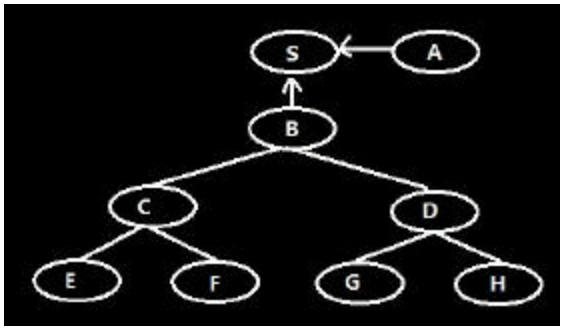

Fig. 1: Schematic diagram of the running speed' influencing factors

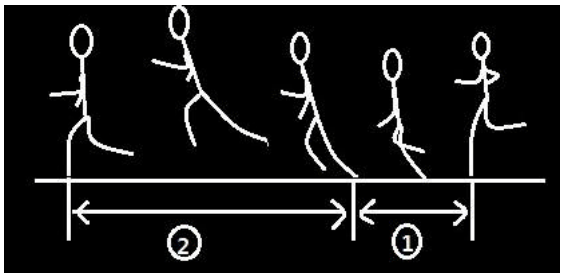

Fig. 2: Two-stage schematic diagram of a cycle in running

Running exercise is a typical cyclical sport; running in a cycle can be divided into two phases, one is grilled kicking phase and the other is the flight phase; by three-phase nodes one cycle of running exercise is divided into two stages. Figure 2 shows a schematic diagram of human motion in a cycle of running exercise.

In Fig. 2, represents stomp stage, Fig. 2 represents flight phase, running from right to left to divide the two phases of a cycle and the three time phases are the landing phase, the lifting phase and the landing phase.

Kinematic characteristics of running: Running speed is equal to step length multiplied by step frequency; step length refers to the horizontal distance in the movement direction of left and right foot's landing points in the running process, that is the sum of the landing distance and the vacated distance; step length is related to the leg length; in sprint there has a high correlation between the step length and the leg length while the correlation in the long run is not big; step time refers to the time necessary for a single step, the average step time of our high-level athlete is 0.216 sec, wherein the support time is 0.088 sec, the flight time is 0.128 sec, the ratio of the support time and the flight time is 1:1.46; stride frequency refers to the numbers of completing a single step in a unit of time.

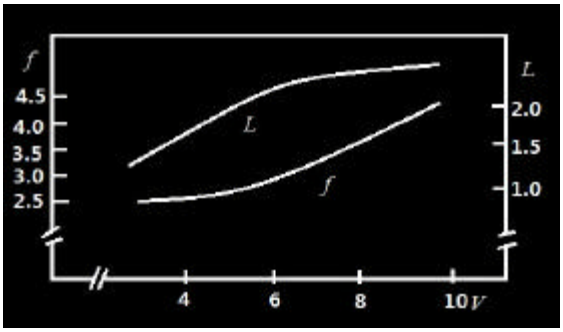

Fig. 3: Change trends of step length and stride frequency with the increasing of running speed

If $\bar{V}$, means average running speed, $\bar{L}$ denotes the average step size, $\bar{f}$ denotes the average stride frequency, $\bar{T}$ represents the average step time, the above parameters satisfy the Eq. 1:

$$\bar{V} = \bar{L} \times \bar{f} = \bar{L} \times \frac{1}{\bar{T}} \quad (1)$$

If the step length $\bar{L}$ in the Eq. 1 is constant, the stride frequency will increase and it is possible to improve the running speed; because the movement trajectory of human body will no longer change in the flight phase of running, in order to improve the step frequency we should make efforts on grilled pedaling stage, the front part of the landing and supporting stage is the scrabble action; purpose of the scrabble action is to make the supporting leg quickly store elastic energy, make the body center of gravity quickly through the supporting point and thus force with the rear pedal; when the proportion of time-consuming in scrabble picking stage to step time increases, it can enhance muscle's flexibility so as to reach the effects of increasing stride frequency.

The unity of step length and stride frequency lies in that the two scores determine the running speed but the blind pursuit of step length, step frequency will inevitably reduce; if blindly chase step frequency, step length will certainly be shortened; so athletes should increase the step frequency based on the increasing of step length; under normal circumstances in the process of running speed increasing the step length and stride frequency will both increase; and when runs fast the step length will no further increase; Fig. 3 shows the schematic of the change circumstance of step frequency and step length with the increasing in running speed.

BIOMECHANICAL ANALYSIS OF RUNNING TECHNIQUE

Biomechanical analysis of starting techniques: Starting position mainly has standing and crouching two types; currently long-distance runners generally use standing type while sprinters generally use crouching type, this study analyzes the crouching starting position.

The crouching start position can reduce the body's front stability angle as much as possible, are beneficial to human body quickly break through the existing stationary equilibrium, can give lower limb muscle power a proper initial length, makes the muscles produce greater contraction forces but also can improve the muscle's elastic energy, can increase the horizontal component of stomp force and helps to increase the body's horizontal speed.

In preparing the starting running, the muscle pulls to a suitable initial length, enhances the "pretension", makes the muscles into operation state ahead, thus obtains greater speed when starting from the pedaling; when both hands lift from the earth, the role of the body will rotate toward the ground taking the foot as fulcrum under the role of gravitational torque but the correct starting position does not make the body move to the ground; the body suffers the reaction force of the ground which goes through the front and bottom side of the body center of gravity; according to the translational theorem of force, we can see the force gives the human body a backward rotation torque, the resistance gravitational torque will not make the body dump forward. At the starting moment the body center of gravity will move forward quickly which breaks the equilibrium state and gets a forward acceleration; the higher the level of the athlete is, the greater the horizontal acceleration of body center of gravity is which is related to the horizontal distance from the starting line and the body center of gravity; the shorter the horizontal distance from the body center of gravity of high-level athletes to the starting line is, the larger the weight the arms bear, thus it is possible to obtain a large horizontal component.

We can use the size of the pedaling force and the forced time to evaluate the effect of starting; it is expressed with the impulse of the pedaling force as shown in Eq. 2 below:

$$I = \int_{t_0}^{t_1} F_1 dt + \int_{t_0}^{t_2} F_2 dt \quad (2)$$

In Eq. 2 I represents the impulse sum generated by the two legs' kicking force, t_0~t_1 means the stomp time of the hind legs, t_0~t_2 means the stomp time of the front legs, F_1, F_2 means the pedal force of the front legs and hind legs, the components of these two forces in the three directions of space have the characteristic as shown in Fig. 4.

Biomechanical analysis of swing technique: In the running process the swing of arms and legs are usually completed synchronization and coordination; if during running process fixing the arms and running only with leg will definitely affect your running speed and therefore, it

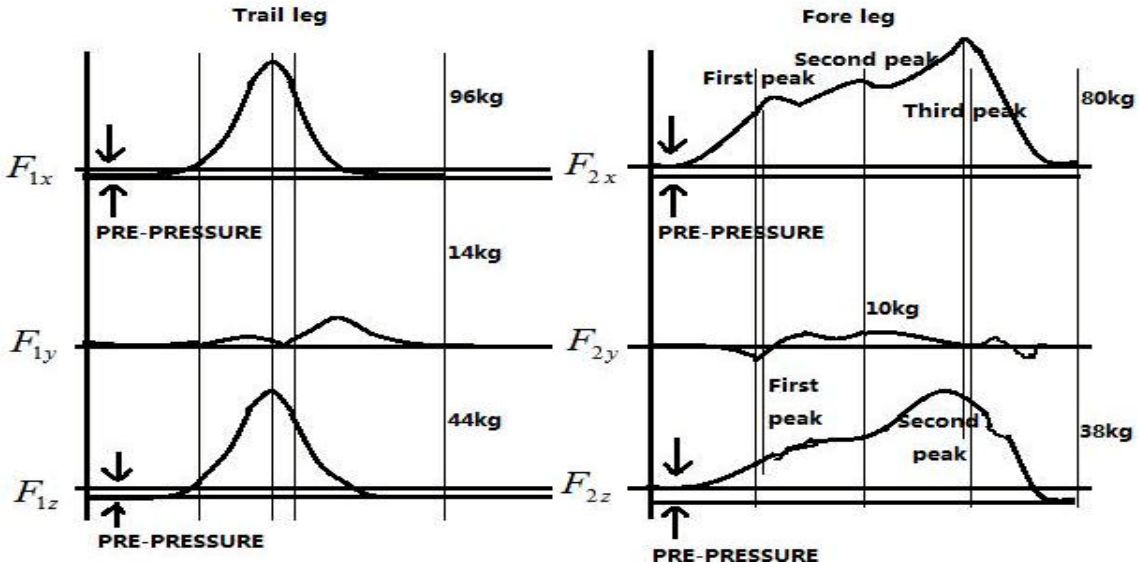

Fig. 4: Characteristic curves of two legs' pedaling force

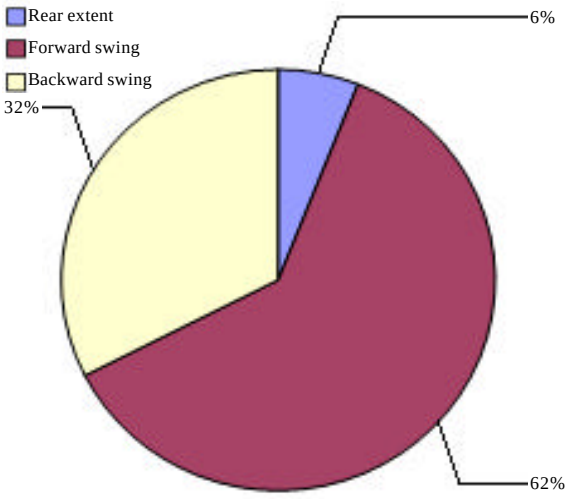

Fig. 5: Three the proportion of three swing phases in the time for the swing leg

needs the coordination of the two arms, for this section in order to focus on study the swing technique; it is assumed that the two arms can both coordinate in the swinging process of the legs, the text reflects only the swinging technique of the swinging leg.

In the current sprint technique, it requires to control the actively kicking and stretching of the swinging leg's hip, knee and ankle joint before the foot lands, so that, the body center of gravity remains stable height and forward. Kicking leg becomes the swing leg when it lifts the ground; in the effect of inertia, the thigh of the swinging leg first stretches and then does the forward swing; the rear extension time is 0.025 0.007 sec; when entering the second single-step lifting instantaneous, the swing leg reaches the maximum swing amplitude, roughly swing 163.7° 10.6°; after the thigh begins front swing, the calf quickly folds knees, when kicking it reaches the maximum flexion degree of 29.8°±2.8°; the knee joint's flexion time is 0.15±0.004 sec; the knee's extension time is 0.15±0.01 sec, i.e., the knee joint's flexion time and extension time are basically the same but the thigh's front swing time is 0.22±0.008 sec, about 1 times of the rear swing time 0.11±0.01 sec.

The swinging of the swinging leg can be divided into the thigh rear protraction, front swing and rear swing three periods, the proportion of three periods is shown in Fig. 5.

When the foot kicks off the ground, the swinging leg thigh first stretches and then quickly swings forward; in the second vacated moment it reaches the maximum swing value, the thigh starts swinging forward, the calf folds

Table 1: Pedaling force's component peak condition in three directions of space

F_X	First peak value	-91.68
	Second peak value	58.44
F_Y	First peak value	43.56
	Second peak value	18.52
F_Z	First peak value	123.84
	Second peak value	235.23
Σ_F	First peak value	144.74
	Second peak value	286.26

knees quickly to reduce the moment of inertia, it reaches the maximum flexion degree when the body is vertical to the support points and the body center of gravity.

Biomechanical analysis of stomp techniques: In the running process the speed of the body will change, from the reasons of the speed changing it is that the human body has been put forth his strength; using sports biomechanics force measuring system can get the law of the body force, from the perspective of dynamics quantitatively analyze the mechanics characteristics of running stomp processes.

The data of Table 1 shows the vertical component is the largest, the average value is 1.38 to 1.61 times of the weight, the maximum value is 2.02-3.43 times of the weight; the size of portrait component force is second to the vertical component, its average value is 0.53-0.63 times of the weight, the maximum value is 0.84-0.97 times of the weight; the transverse component force is the smallest, the average value is 0.11-0.16 times of the body weight, the maximum value is 0.32-0.42 times of the body weight. The joint pedal force has two peaks and two troughs and the peak value of the second peak is about twice as the peak value of the first peak; the longitudinal pedal force also appears two peaks but the first peak is negative, the second peak is positive; the negative value indicates that the movement of the human body generates resistance, the positive value indicates that the movement of the human body generates power.

The enclosed area of pedal force curve and the time axis is equal to the impulse of force; the physical meaning of the impulse is the cumulative effect of force over time, you can use this physical quantity to evaluate the pedaling force effect on foot. The impulse of the kicking force is the main factors of running speed; the impulse generated by the force has braking effect and power effect; in order to increase the running speed sound stomp technology should reduce the braking impulse and increase power impulse; the specific methods to reduce braking impulse have the following three methods:

- When the supporting legs touch the ground, the hip joint should not participate in the buffer activity but should uninterruptedly stretch it

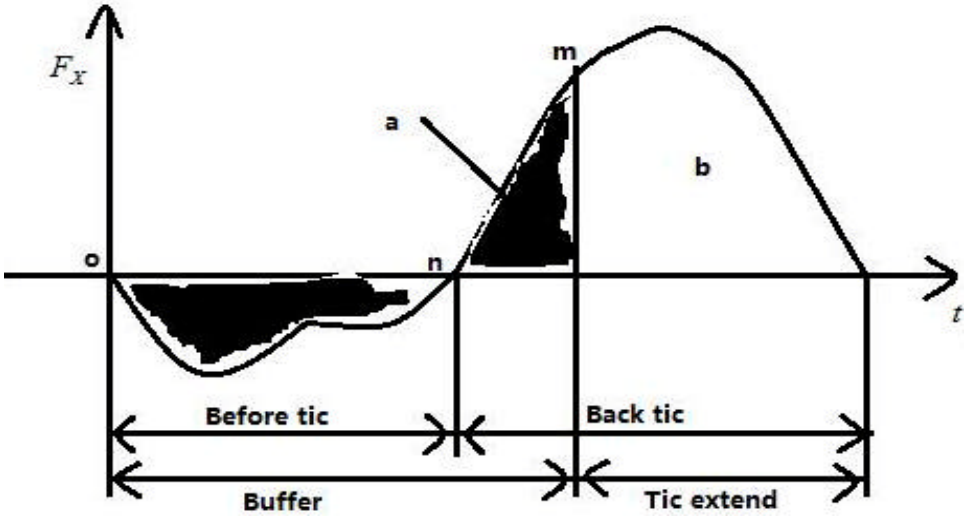

Fig. 6: Horizontal impulse of front pedaling and rear pedaling two stages

- Increasing the landing angle, reducing the level of resistance and the action time is conducive to reduce the resistance impulse
- When the foot touches the ground, you should strive to reduce the relative velocity of the feet and the runway

Pedal force's impulse generates impulse size of kicking source on the horizontal component; the curve of the pedaling force component in the horizontal direction for the front kicking and rear kicking two stages is shown in Fig. 6.

Buffer stage shown in Fig. 6 is that the knee joint of the supporting leg does concede work; so, the impulse at this stage is to extend the knee muscles and do eccentric contraction, complete concession works and its size depends on the effect of swinging action and the concession contractility of the knee joint; the impulse size of the kicking stage is b; it is produced on the basis of the previous action, generated by the stretching movements of knee joint and ankle joint; and its size depends on the size of the restraint work capacity of the knee joint and ankle joint muscle and the acceleration values of the swing motion.

Through the above analysis, the pedal force is mainly generated by the swing movement and kicking two technologies and the supporting legs complete the pedaling action in the form of concessions and restraint two kinds of contraction. If you want to increase the power impulse, the body needs to combine the kicking and pedaling action of the whole body, by increasing the buffer range of motion, increase the motion range of the knee and ankle joints' stretching actions and reduce the rear kicking angle, thereby increase the horizontal component and impulse of the kicking force, increase the power impulse.

In the buildup running stage the impulse $F_z \bullet t$ of the longitudinal force is significantly greater than the impulse of the longitudinal force on the way out; with the proceed of speed buildup, it has gradually reducing trend which is due to the leaning forward amplitude is large in the running buildup stage and it is conducive to obtain the impulse of the longitudinal force. So, as to obtain a large acceleration as far as possible and maintain the maximum speed of the running stage, the body needs to minimize the braking impulse to increase the impulse force.

CONCLUSION

In this study, it summarizes the factors affecting the running speed, draws two main parameters affecting running speed, namely stride frequency and stride length; it analyzes the variation pattern of the step length and stride frequency with the increasing of the running speed, obtains the increase of the step frequency is the main way to improve running speed, in order to increase the running speed, simultaneously increasing step length and stride frequency can achieve perfect results; it conducts a biomechanical study for starting techniques, explores the kicking force curves of the starting process and provides a theoretical

basis for the study of starting technology; it conducts research on swing technology of running, focuses on the analysis of each stage's time interval of the movement leg in the swing process, obtains the time proportion of the thigh rear stretch, front swing and rear swing three periods and gives the causes of the swing technology on the running speed; it conducts analysis of stomp technology in running processes, through the data research on the kicking force of running, derives the characteristics of the lateral, longitudinal and vertical component force for the pedal force, studies the generating principle of power impulse and braking impulse, gives the method to increase power impulse and reduce braking impulse.

REFERENCES

Chen, C. And X.M., 2012. The importance of the hip action in track and field technicals. J. Hubei Sports Sci., 31: 491-493.

Deng, X.M., 2011. Explore the mechanics of running exercise. Phys. Bull., 7: 95-98.

Tan, Z.J., 2013. Fuzzy data envelopment analysis and neural network evaluation mathematical applications model which based on martial arts competition. Int. J. Applied Math. Stat., 44: 37-44.

Zhang, B., 2013. Dynamics mathematical model and prediction of long jump athletes in Olympics. Int. J. Applied Math. Stat., 44: 422-430.