THE EFFECTS OF EXERCISE-LOAD DURATION ON THE KINETIC CHARACTERISTICS OF VERTICAL JUMPS

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The purpose of this study was to identify the relationships between exercise-load duration and the kinetic characteristics of vertical jumps. Twenty-two male students majoring in physical education acted as volunteers. In this study, prolonged duration of exercise with the same amount of load was analyzed. Component forces and impulses were increased in the right, left, up, down, forward and backward directions. The torque produced in these directions increased with the prolonged duration of exercise. Therefore, a faster and more efficient method of judging sport fatigue and its degree could be accomplished by the post-exercise kinetic index—component force, impulse and torque.

KEYWORDS: exercise-load, duration, vertical jump, kinetic characteristics, sport fatigue

INTRODUCTION: Previous research has shown that prolonged exercise duration produces the corresponding changes in the function of human tissues and systems, with the ultimate result of sport fatigue. Fatigue can be manifested in the form of individual sensations and in observable physiological changes. In addition, there may be changes in the biomechanical index (exercise index). Research has shown that a fatigued human body can demonstrate maximum strength and speed (Siler, 1991), with changes accordingly reflected in the kinematic and kinetic characteristics, Therefore fatigue research by means of biomechanical analysis could produce meaningful information (Lu, 1998). The aim of this research was to examine the effects of exercise-load duration on the kinetic characteristics of vertical jump performance, with a view to establishing a biomechanical index for sport fatigue research. This data could serve as an important reference for coaches and athletes in the control of exercise-load during training.

METHODS: The subjects selected for this study included twenty-two physically and mentally stable male students majoring in PE, who volunteered to take part in the test. Their average age was 21.5±0.9 years, weight 68.9±5.5 kg, height 1.74±0.05 m. Before they were tested, all the subjects learnt to perform squat jumps with their arms akimbo and their knees forming an angle of 105°.
The whole test was divided into four sessions and in each session the subjects had to complete one squat jump on the force meter (JY5001-8). There was no exercise-load for the first experiment. For the next three tests, the subjects had to pedal for 3, 5 and 7 minutes respectively on a bicycle ergometer (250w, Phoenix TJ-205A) before the time was recorded. One recording was completed every two weeks. The sampling and analyzing of all data was accomplished by computer programming.

RESULTS: Figure 1 illustrates the changes of component forces, impulses and torque in the right and left (x), forward and backward (y) and upward and downward (z) directions when squat jumps were being performed in the four successive test sessions. The findings were that all the kinetic indexes, except for those of the vertically directed component forces and impulses, showed a steady rise as the exercise-load increased.
All the indexes showed no difference between no-load duration and three-minute load duration (See Table 1). However, vertically directed component forces and impulses showed a marked drop ($p<0.01$) when load duration reached five or seven minutes whereas all the other indexes displayed a sharp rise ($p<0.01$).

DISCUSSION: An ideal force-exertion in vertical jump performance should have precise vertical direction, but is unattainable for the human body. As a result, component forces and impulses in the right and left as well as forward and backward directions would inevitably accompany the process of vertical jump performance, though they were meaningless to the performance.

With the prolonged exercise-load duration came an obvious drop in component forces and impulses in the vertical direction. A continuously-exercised human body demanded a consumption of ATP, CP contained in muscles; the result was that the muscles' output ability decreased, leading to less force acting on the ground due to the contraction of muscles, a fact that explained the fall of vertically-directed component forces and impulses. Researchers held different views about the correlation between vertically-directed component forces and the ability of vertical jump, but almost every researcher agreed upon the close relationships between vertically-directed impulses and the ability of vertical jump (Lu, 1999). The component forces and impulses after five or seven minutes' jump performance displayed a marked decrease, therefore, vertically-directed component forces and impulses could be used to judge the degree of sport fatigue.

During vertical jump performance component forces and impulses in the right and left as well as forward and backward directions are related to the extent to which a human body's swinging movement is coordinated with the legs' stepping action. A fatigued body would display a weakened control of central nervous system over muscles. Therefore, as fatigue increases in a human body due to prolonged exercise-load duration, an inevitable consequence would be the rise of component forces and impulses in the said directions, which could also be used to judge the occurrence and development of sport fatigue.

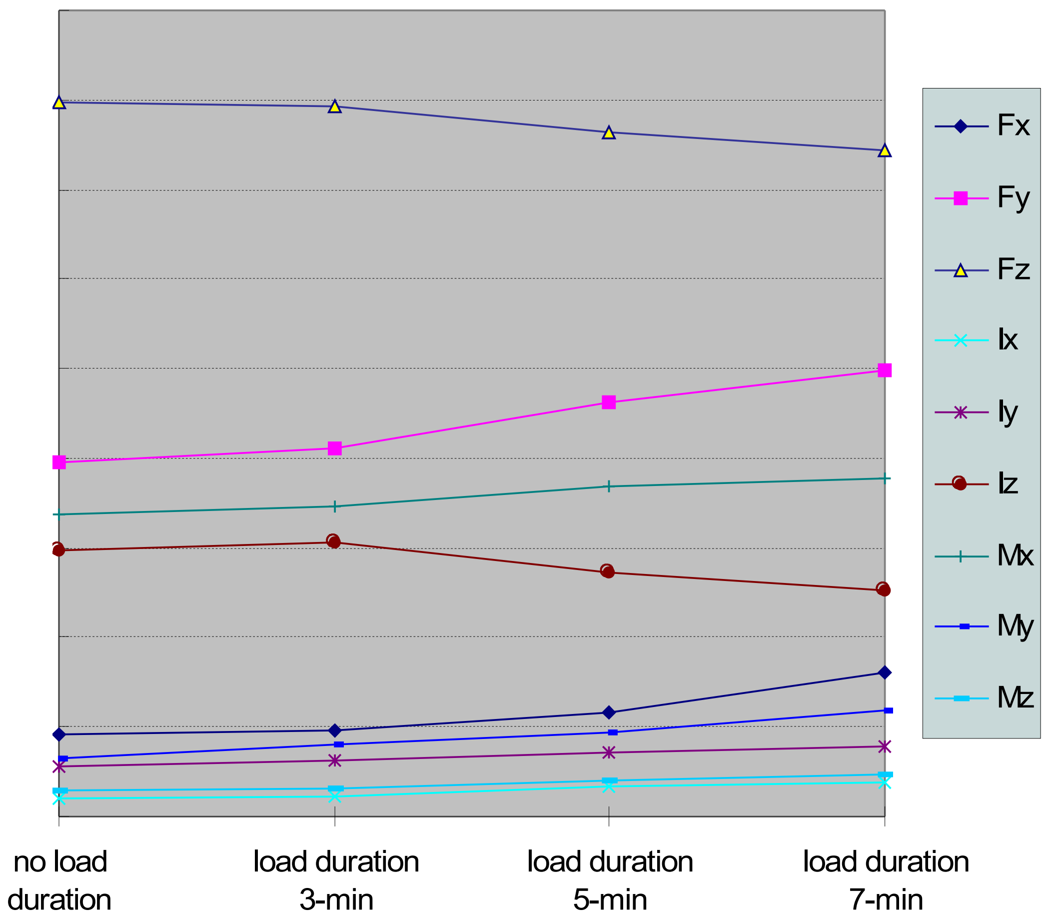

Figure 1 - Changes in the kinetic characteristics of vertical jump under difference load

duration.

Table 1 Comparison of the Effects of Exercise-load Duration on the Kinetic Characteristics of Vertical Jumps

Index	no load duration M±SD	load duration 3-min. M±SD	load duration 5-min. M±SD	load duration 7-min. M±SD
F_x *(N)*	45.8±11.4	48.0±9.7	57.6±9.1	79.9±14.6
F_y*(N)*	198.2±28.0	205.4±30.2	231.5±27.9	249.5±29.7
F_z*(N)*	1993±175	1983±208	1912±219	1859±205
I_x*(Ns)*	5.2±1.7	5.8±2.2	8.1±2.6	9.6±2.3
I_y*(Ns)*	14.2±3.3	15.7±4.0	17.6±4.4	19.8±4.5
I_z*(Ns)*	148.2±20.1	152.9±19.0	136.7±21.2	126.2±23.4
M_x*(Nm)*	169.1±30.7	173.1±32.9	184.7±36.7	188.6±36.7
M_y*(Nm)*	15.7±5.6	19.8±9.0	23.7±10.5	29.9±14.8
M_z*(Nm)*	7.1±2.7	8.0±2.5	10.2±2.8	12.2±3.5

In vertical jump performance no torque would appear in all directions if the forces exerted were directed upward. However, the emergence of torque in body exercise was a natural event, and was an indication of the loss of mechanical efficiency of the working muscles; this loss was getting ever clearer as exercise-load duration was prolonged. Whether the torque was large or small in vertical jump reflected not only the efficiency of a human body's exercise of its forces but also the degree to which the muscles were exerted.
After a three-minute bicycling activity, the kinetic indexes in vertical jump displayed no difference between duration without load and three-minute load duration. According to the related theories concerning biomechanics, a human body in continuous exercise will exhibit an improved and stabilized period in its exercise ability, with fatigue appearing only after more exercise. The results of the present study confirmed the theories.

CONCLUSION: Different exercise-load duration can produce changes of component forces, impulses and torque in all directions in vertical jump performance, and these changes are identical with the changes in a human body's exercise capability. By referring to the post-exercise kinetic indexes (component forces, impulses and torque in all directions) as an indication of judging fatigue together establishing degree, a feasible yet highly efficient method can be established.

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