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Evaluation and Quantification of Running Motion.

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INTRODUCTION

To the present there have been many magazines and textbooks of good motion of running. Some of them have similar explains, but other ones have their own theory. Since these contents are often described in a qualitative manner, it is difficult to adapt these theories on one's own running style directly. On the other hand, there were many biomechanical studies of the running in the field of sports biomechanics. In the past study, it has been reported that the efficiency of running should classified into 'efficiency', 'economy', and 'effectiveness' when we know the energy flow in the human movement[1,2,3]. Williams and Cavanagh[4] indicated that biomechanical variables of running were identified which showed significant differences between groups separated on the basis of $\dot{V}O2_{submax}$. However, it appeared that no single variable can explain differences in economy between individuals. As just described, there are still many problems remaining that it is difficult to apply same logic to every runner because there are great differences between individuals and that it is very important to feedback the results of evaluation then and there. The purpose of this study was to know the relationship between objective data which include kinetics and kinematics data and subjective evaluations of running motion of various runners which were judged by coaches and researchers. Furthermore, we tried to make the scoring method which can evaluate running motion immediately and quantitatively.

METHODS

Participants

Twenty males and fifteen females subjects aged 22-50 years (age = 37.4±9.6 years; Height = 1.66±0.08m; Body weight = 57.5±8.7kg) gave informed consent to participate in this study. They were free of any serious injuries at the time of study, although they were not elite athletes. On the other hand, we selected 12 persons as evaluators of running motion. They had enough experience of coaching or had sufficient knowledge of biomechanics.

Tasks

Subjects performed both 5 trials of track running at 2.78± 0.14m/sec test speed and 30 seconds trial of treadmill running at 2.78m/sec test speed with same running shoe (Wave Rider12, Mizuno).

Procedure

Three-dimensional kinetics and kinematics were captured using a Kistler force plate and 12 infrared camera system (Mac3D System, Motion Analysis Corp) at a data sampling rate of 500Hz. The ground reaction force was measured simultaneously with the track running. Each subject was instrumented with 41 reflective makers and recorded video pictures of back view and side view of treadmill running. After trials, evaluators scored subject's performances of recorded video picture considered as a running style for marathon race. In rating, there were totally 9 descriptions (Pace, Style, Secure, Rhythm, Relax, Dynamic, Smooth, Balance, Total) in the 7-grade evaluation, which typically used for describing running style.

Data Processing and Statistical Analysis

Categorizing variables In fact, the grading parameters were initially correlated with each other. So, we summarized 8 parameters into some representative parameters by means of factor analysis.

Selecting the number of factors For each representative parameter, correlation coefficients with all kinetics and kinematics parameters were calculated individually and screen out the inessentials. After that, highly selected parameters were summarized into few parameters by means of factor analysis to know the fundamental parameters to explain descriptions by kinetics and kinematics parameters.

Formation of a multiple regression equation We used multiple regression analysis to make multiple regression equation based on kinetics and kinematics data. After that, we made score calculation formula of running movement.

Validation of high score motion In order to evaluate the advantages of high score movement, we found the subjects who have similar height and weight but have big gaps on the score. Furthermore, we calculated muscle force using a musculo-skeletal model (ARMO, G-sport, Japan) and kinetic energy to understand the differences between high score motion and low score one.

RESULTS

Categorizing variables By means of the factor analysis, we found that the first axis means 'Secure' and the second axis means 'Dynamic' or 'Pace'. In addition to these results, the other descriptions were positioned very closely on scatter plot and they have close contacts with these factors.

Selecting the number of factors According to single regression analysis, kinetics and kinematics parameters were assembled into 90 parameters in 'Dynamic', 50 parameters in ‘Secure’. Furthermore, these parameters were classified into 10 groups by means of multiple regression analysis. The representative parameters of ‘Dynamic’ were (1)shank segment angle on sagittal plane, (2)upper arm segment angle on sagittal plane, (3)thigh segment angular velocity on sagittal plane, (4)shank segment angular velocity on sagittal plane. Meanwhile, the representative parameters of ‘Secure’ were (1)thigh segment angle on frontal Plane, (2)lower arm segment angle on sagittal plane, (3)body-mass index (Table.1).

Formation of a multiple regression equation By means of multiple regression expression, we calculated multiple regression equation based on these representative parameters. The determination coefficient values of each ‘Dynamic’ and ‘Secure’ were 0.76 and 0.74 using a 0.01 level of significances for inclusion in the regression. And the description ‘Total’ was described with the term ‘Dynamics’ and ‘Secure’. The determination coefficient value of equation was 0.84 using a 0.01 level of significances (Figure.1).

‘Total’= **-** 17.69+0.582*’Dynamic’ +0.671*’Secure’.

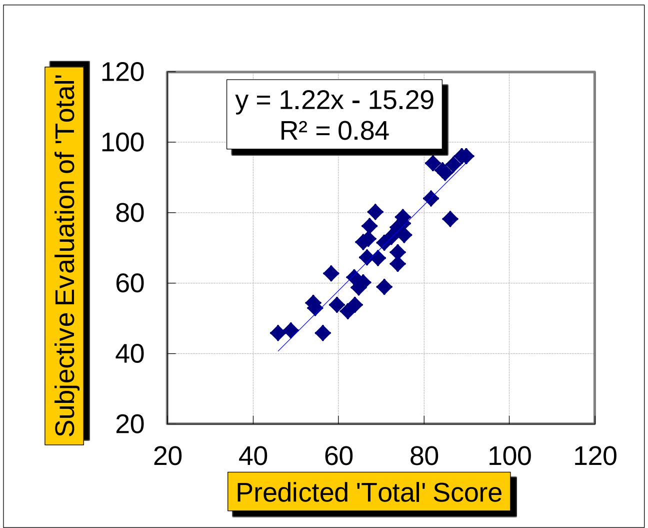

Figure.1 Relation between predicted scores and subjective evaluations of ‘Total’.

Validation of high score motion According to simulation results of ARMO, Total amount of energy which consist of translational energy and rotational kinetic energy of all segments were greater on low score data than high score data. In addition, muscle power of ankle dorsiflexion, knee extension, hip extension, and hip abduction were also greater on low score.

DISCUSSION

Despite the meanings of the words were explained according to evaluator’s own idea, the descriptions were classified into only few parameters by means of factor analysis. This fact indicates that each description carry a great deal of meaning. That is to say, they may include similar interpretation to explain the motion. Due to this, they can summarize into few parameters. On the other hand, the multiple regression equation has an enough accuracy to explain the prediction data although it consists of only few parameters. It was found from the result that this equation make the connection between subjective data and objective data clearly. The results of this study are different from that of past study [4]. In this study, it found big differences in angular velocity of lower segment on sagittal plane. But past results indicated that there were big differences in planter flexion angle and trunk angle on sagittal plane. These differences may affected by running speed and runner’s skill. From the results of kinetic energy and muscle activities, it is assured that the movements of high score runner have an advantages in efficiency. Therefore, not only in subjective evaluation but also in objective evaluation there are advantages in high score motion.

CONCLUSIONS

Based on these results, it is concluded that subject evaluation of running movement can combine with objective data directly and that running movement can evaluate in a quantitative way. And it appeared that high score motion have advantages in efficiency.

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Table.1 Results of factor analysis.

Description	Parameters	Coefficient of correlation
Dynamic	Thigh segment angular velocity on sagittal plane	-0.64
	Shank segment angle on sagittal plane	-0.61
	Shank segment angular velocity on sagittal plane	-0.60
	Upper arm segment angle on sagittal plane	-0.47
Secure	Thigh segment angle on frontal Plane	-0.64
	Body-mass index	-0.60
	Lower arm segment angle on sagittal plane	-0.56