筋群制御の観点での体幹の強さの定量的評価基準の調査

Quantifying Core Strength in Viewpoint of Neuromuscular Control

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Abstract: Improving core strength is critical in reducing lower back pain and preventing falls. Core strength consists of two components: muscle strength and neuromuscular control ability. Most existing studies on core strength focused on evaluating and improving muscle strength, endurance and flexibility. Less attention, if any, was given to neuromuscular control. However, several studies suggested that maintaining sufficient core stability when performing daily living is not compromised by insufficient muscle strength, which implies that alongside muscle strength, neuromuscular control is important aspect characterizing core strength. Based on discussions with dancesport professionals, we narrowed down our focus on center of gravity control (CGC) as a key metric of core neuromuscular control. We first defined two standard movements for measureing CGC, i.e, waltz rotation and merengue shake. We then conducted preliminary measurement with a dance professional when she performed these two movements with intensionally good or bad CGC. The trajectory of center of gravity was measured using Nintendo Wii Board, while the acceleration and gyro of the movements were measured using AxisVisualizer, a mobile app for visualizing core strength. The measurement results produced implications for quantifying CGC using kinesiology metrics.

Key Words: Core Strength, Neuromuscular Control, Human Science, Health Promotion, Dancesport,

1. Introduction

Improving and maintaining body core strength is an important aspect of healthy aging, as weak core is directly related to lower back pain and fall accident in aged population. Core strength is generally defined as the ability to achieve and sustain control of the trunk region at rest and during precise movement, which consists of muscle strength and neuromuscular control [1]. Although research on body core in sports science has dominantly focused on improving muscle strength, there is evidence that neuromuscular control is even more critical in providing sufficient core strength and is yet not strongly associated to core muscle strength [2]. Most fall accidents were more due to loss of balance on center of gravity during movement than due to weak core muscle. In support of this view, we focus our study on an important aspect of neuromuscular control, i.e., center of gravity control (CGC). Smooth CGC requires the usage of inner muscle and good neuromuscular control, and it is critical for normal functioning in daily life.

2. Defining Standard Movements

In order to measure center of gravity control (CGC) during movements, we first need to define typical movements that satisfy the following three requirments:

Fig.1 Waltz Rotation

- The movement involves continuous shift of center of gravity.
- The movement involves intensive usage of hip joint.
- The movement can be easily performed by any person.

Based on the discussions with dance professionals, we selected the following two movements.

・ Standard Movement 1: Waltz Rotation
・ Standard Movement 2: Merengue Shake

Fig.2 Merengue Shake

3. Preliminary Measurement

The center of gravity during movement is not directly visible and we are not consciously aware of it when we move. Naturally the next question is what are the key kinesiology and neurology attributes that best distinguish good and bad CGC. Clarifying these attributes is indispensable for automatic evaluation of CGC.

Table 1. Measuring Devices and Measured Attributes.

Devices	Measured Attribute
Nintendo Wii Balance Board [3] + FitTri	Horizontal projection of center of gravity trajectory
Axis Visualizer [4]	3-D acceleration and gyro

In the current stage, we focus on clarifying key kinesiology attributes that quantifying CGC. Traditionally, force sensors such as force plate and pressure distribution measurement devices are needed for dynamic analysis of movement. However, such devices are expensive and require special techniques for their operation, thus are not suitable for daily use by non-expert. As alternatives, we used the devices summarized in Table 1 to measure the candidate kinesiology attributes, which are affordable and convenient for daily use. We will investigate neurology attributes in the next stage.

The center of gravity trajectories measured using Wii Balance Board are shown in Fig. 3. Good CGC was characterized by keeping the center of gravity forward during motion, wider motion range, approximate symmetry, and smoothness. The trajectories of acceleration and gyro for Waltz Rotation and Merengue Shake are shown in Fig. 4 and Fig. 5 respectively. As is shown in Fig. 4, good and bad CGC for Waltz Rotation may be best distinguished by the projection of acceleration and gyro in X-Z plane. As for Merengue shake, all attributes may distinguish good and bad CGC.

4. Summary and Future Work

In this study we attempted to quantify core strength in terms of neuromuscular control. Based on the discussions with dance professionals, we narrow down our focus to center of gravity control (CGC) during movements. We defined two standard movements, i.e., Waltz Rotation and Merengue Shake, which are easy to perform for the evaluation of CGC. We preliminary measured the trajectory of CGC and acceleration with a dance professional when she performed these two movements with intensionally good or bad CGC. The results showed that the trajectories of good and bad CGC demonstrated distinct characteristics. The preliminary measurement indicates that the shape of center of gravity trajectory, acceleration, and gyro may all be used to distinguish good and bad CGC. In our next step, we plan to conduct measurement with people who have diverse core strength to identify key attributes that best distinguish the good and bad CGC.

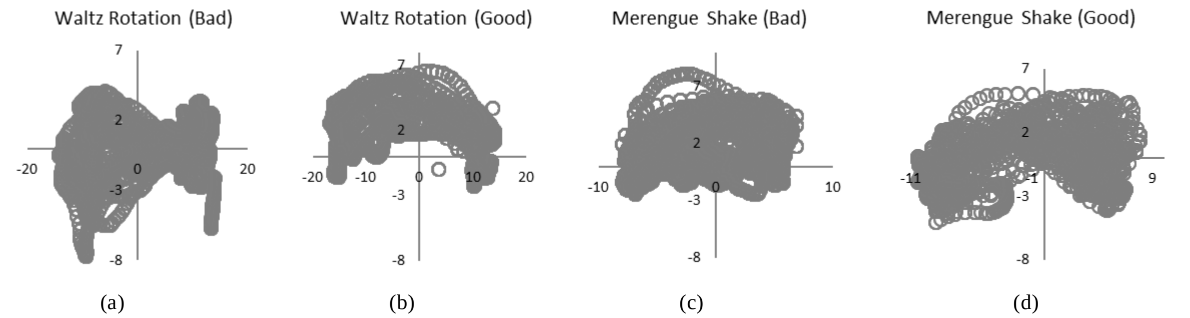

Fig.3 Trajectories of center of gravity (unit: cm). (a) Bad center of gravity control (CGC) for Waltz Rotation; (b) good CGC for Waltz Rotation; (c) bad CGC for Merengue Shake; (d) good CGC for Merengue Shake.

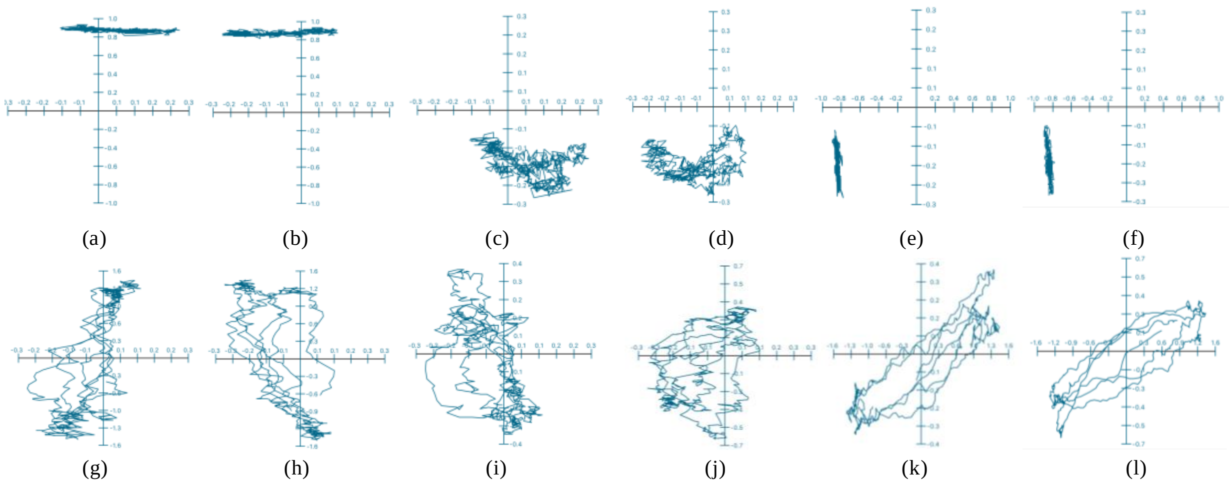

Fig.4 Trajectories for Waltz Rotation (unit: m/s^2 or / s^2). (a) Acceleration in X-Y plane (bad CGC); (b) acceleration in X-Y plane (good CGC); (c) acceleration in X-Z plane (bad CGC); (d) acceleration in X-Z plane (good CGC); (e) acceleration in Y-Z plane (bad CGC); (f) acceleration in Y-Z plane (good CGC); (g) gyro in X-Y plane (bad CGC); (h) gyro in X-Y plane (good CGC); (i) gyro in X-Z plane (bad CGC); (j) gyro in X-Z plane (good CGC); (k) gyro in Y-Z plane (bad CGC); (l) gyro in Y-Z plane (good CGC).

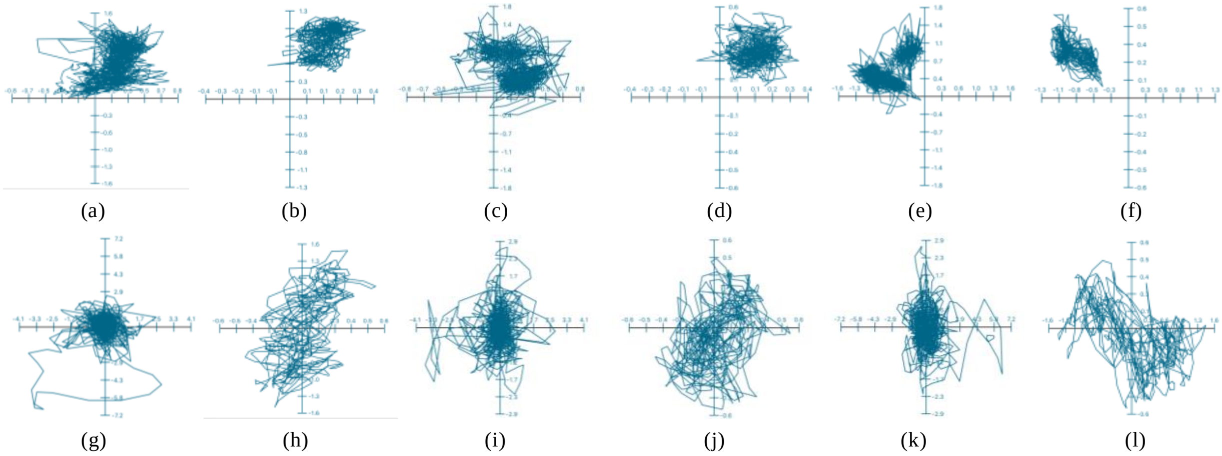

Fig.5 Trajectories for Merengue Shake (unit: m/s^2 or / s^2).. (a) Acceleration in X-Y plane (bad CGC); (b) acceleration in X-Y plane (good CGC); (c) acceleration in X-Z plane (bad CGC); (d) acceleration in X-Z plane (good CGC); (e) acceleration in Y-Z plane (bad CGC); (f) acceleration in Y-Z plane (good CGC); (g) gyro in X-Y plane (bad CGC); (h) gyro in X-Y plane (good CGC); (i) gyro in X-Z plane (bad CGC); (j) gyro in X-Z plane (good CGC); (k) gyro in Y-Z plane (bad CGC); (l) gyro in Y-Z plane (good CGC).

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