

## Trunk Balance Evaluation in Adolescent Athletes and Gender Difference using the Dynamic Sitting Balance Device

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### Abstract

**Objective:** The purpose of this study was to quantitatively measure the trunk stability of adolescent athletes using a recently developed, plane-specific, dynamic trunk stability measuring device and to examine gender differences.

**Methods:** This was a cross-sectional study to confirm the difference in dynamic trunk stability between male and female adolescent athletes ranging in age from 12 to 15 years. 15 adolescent athlete cohort was divided into 2 groups by gender. In the dynamic trunk balance evaluator that we developed, the seating surface can be vibrated at a constant cycle (0.2 Hz, 0.4 Hz, 0.6 Hz), the pressure of the seating surface under vibration is detected by three small force sensors installed under the seating surface, and the center of pressure (COP) can be calculated. Measurements were performed for 30 s by one examiner, and each participant was measured three times after two practice attempts. While the seating surface was swaying, the participant's gaze was fixed to a mark about 1 cm in diameter set at a position 2 m in front of the participant at eye height, and the participant was asked to maintain the position of the head constant. The fluctuation of the center of gravity on the seat surface over time was measured, and the total trajectory length of the COP was used as the evaluation item.

**Results:** There were no adverse events during measurement. The results for the total COP trajectory length of male was  $2365 \pm 176$  mm, and that of female was  $2674 \pm 293$  mm. There were significant differences between the male and female groups. In particular, adolescent female athletes had less dynamic trunk stability in the coronal plane.

**Conclusion:** Adolescent female athletes had less dynamic trunk stability in the coronal plane than their male counterparts. The recently developed device may be a useful tool for assessing the effects of prevention programs on dynamic core stability.

**Keywords:** Trunk balance; Adolescent athletes; Gender difference; Dynamic sitting balance

### Background

Core stability is related to the function of the lower extremities and injuries [1-3]. A recent review reported that there is an association between impaired core stability and the development of lower extremity injuries in healthy athletes [4]. The role of core stability has also attracted attention as it relates to the gender difference in ACL tears [5]. In addition, lateral plane displacement of the trunk could predict knee injury risk for female athletes [6]. Evaluation of trunk balance is necessary for predicting and preventing sports injuries.

There are some reports of the quantitative evaluation of trunk stability using an unstable chair with a spring or other methods [7-9]. While the trunk balance-evaluating apparatuses using unstable chairs that have been reported so far were all equipped with a plate to assist the lower limbs, the effects of the lower limbs on measurement could not be excluded.

We have carried out quantitative evaluation of trunk balance with a plane-specific dynamic trunk stability measuring device that we developed. The device can measure dynamic trunk stability without the effects of the lower extremities. We have previously reported its usefulness [10,11]. However, we have not performed a quantitative assessment of trunk balance of adolescent athletes. In addition, we could not find any other report that mentioned quantitative assessment of trunk stability in adolescent athletes and its gender differences.

The purpose of this study was to quantitatively measure the trunk stability of adolescent athletes using our device and to examine gender differences.

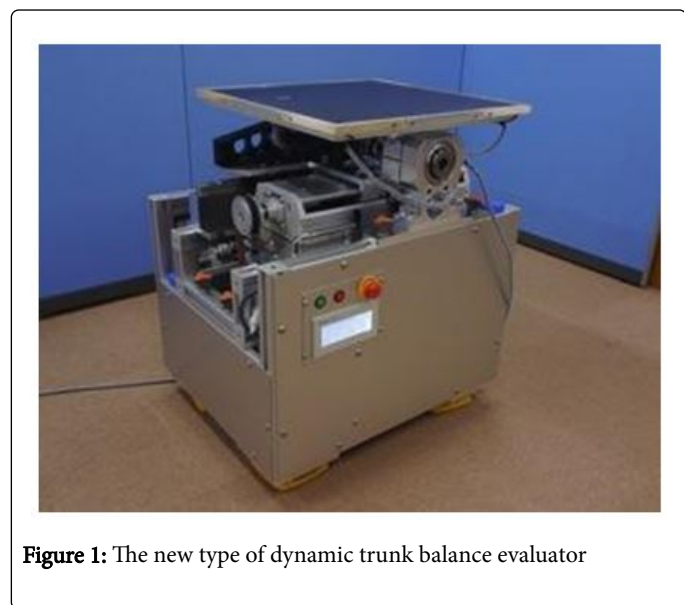
### Materials and Methods

This was a cross-sectional study to confirm the difference in dynamic trunk stability between male and female adolescent athletes.

The participants were healthy adolescent athletes ranging in age from 12 to 15 years. 6 male junior high school students (mean age,  $13.7 \pm 0.5$  years) and 9 female (mean age,  $13.7 \pm 0.8$  years). They were all involved in basketball and badminton in Akita prefecture in Japan.

Data collected included age, class, gender, height, weight, and participating sport of the athlete. The athlete cohort was divided into 2 groups by gender. Exclusion criteria were: a disease preventing exercise; previous spinal surgery; pharmacological therapy for some disease; communication disabilities; and those judged unsuitable as participants.

Figure 1 shows the dynamic trunk balance evaluator that we developed and used in this study. The seating surface can be vibrated at a constant cycle (0.2 Hz, 0.4 Hz, 0.6 Hz), the pressure of the seating surface under vibration is detected by three small force sensors installed under the seating surface, and the center of pressure (COP) can be calculated. The measurement was performed by one examiner, and each participant was measured three times after two practice attempts. The participants adopted a sitting position with the lower limbs completely separated from the floor surface on the measuring device, and the arms were crossed at the front of the chest to eliminate the effect of the upper limbs. In this state, the platform was tilted to the left and right at a front face inclination angle  $\pm 7^\circ$ , with two cycles in 10 s (0.2 Hz).



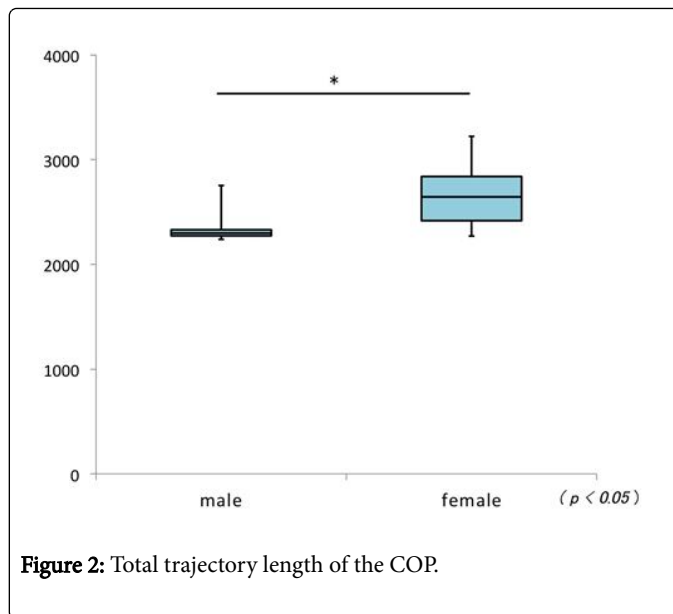
**Figure 1:** The new type of dynamic trunk balance evaluator

While the seating surface was swaying, the participant's gaze was fixed to a mark about 1 cm in diameter set at a position 2 m in front of the participant at eye height, and the participant was asked to maintain the position of the head constant.

Measurement was then performed for 30 s. The fluctuation of the center of gravity on the seat surface over time was measured, and the total trajectory length of the COP was used as the evaluation item.

The purpose, method, privacy protection, etc. of this research were explained to each potential participant, and written, informed consent was obtained from each one.

To analyze the participants' data, the non-parametric Wilcoxon signed-rank test was used to investigate the difference in performance between male and female participants in Figure 2. The significance level was  $p < 0.05$ .



**Figure 2:** Total trajectory length of the COP.

## Results

Table 1 shows the outline of the participants. There were no adverse events during measurement. The results for the total COP trajectory length measured with our dynamic trunk balance device are shown in Table 2. That of male was  $2365 \pm 176$  mm, and that of female was  $2674 \pm 293$  mm. There were significant differences between the male and female groups ( $p = 0.034$ ). In particular, adolescent female athletes had less dynamic trunk stability in the coronal plane.

Characteristic	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)
Age (y)	13.7 $\pm$ 0.5	13.7 $\pm$ 0.8
Height (cm)	176.7 $\pm$ 4.1	162.9 $\pm$ 4.0
Weight (kg)	67.5 $\pm$ 6.2	50.4 $\pm$ 3.9
BMI (kg/m <sup>2</sup> )	21.6 $\pm$ 2.2	19.0 $\pm$ 0.8
SD: Standard deviation		

**Table 1:** General characteristics of participants.

	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)
COP (mm)	2365 $\pm$ 176	2674 $\pm$ 293
SD: Standard deviation		

**Table 2:** The results for the total COP trajectory length.

## Discussion

Adolescent female athletes had less dynamic trunk stability in the coronal plane than their male counterparts according to the assessment device used in this study.

Female athletes have less dynamic postural stability than male athletes in the coronal plane, and this has been noted in association with non-contact ACL injury [12]. Core stability has been reported to

predict ACL injury risk in female athletes [6]. We discovered the same tendency in adolescent athletes.

The risk of non-contact ACL injury is significantly higher in female than male athletes [13-15]. Previous studies suggested that coronal plane trunk stability and ligament injury risk were related [4,6,16]. The findings in the current study with our dynamic trunk evaluator may provide the reason for the gender differences in ligament injury risk.

Our device applies a disturbance in the coronal plane direction and can easily evaluate dynamic stability in the coronal plane quantitatively. This device may be a useful tool for assessing the effects of prevention programs on dynamic core stability. This is the first study to quantitatively evaluate the gender difference of the trunk balance of the adolescent athletes. Furthermore, we will consider the relationship between trunk stability measured by our device and lower limb injury risk in a future study.

As limitations of this study, there were few participants, and the evaluations were all done on the same day. The activity levels of the athletes were not evaluated. Furthermore, the results were not compared with those of other clinical laboratory methods and muscle strength. And future research will expand and extend the populations under study.

## Conclusion

Adolescent female athletes had less dynamic trunk stability in the coronal plane than their male counterparts. The recently developed device may be a useful tool for assessing the effects of prevention programs on dynamic core stability.

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