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Original Article

Correlation between ankle plantar flexion strength and degree of body sway

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Abstract. [Purpose] The purpose of this study is to consider the correlation between ankle plantar flexion strength and degree of body sway. [Participants and Methods] Twenty-one healthy adult males were targeted. A handheld dynamometer was used to measure ankle plantar flexion strength. The Body Pressure Measurement System was used to measure the degree of body sway. Lastly, correlation between ankle plantar flexion strength and degree of body sway was considered. [Results] A negative correlation was observed between ankle plantar flexion strength and degree of body sway. [Conclusion] Regarding ankle plantar flexion strength and degree of body sway, results of a consideration using a handheld dynamometer and Body Pressure Measurement System were the same as that of previous studies using large equipment.

Key words: Ankle plantar flexion strength, Degree of body sway, Small device

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INTRODUCTION

There is a large difference in activity between people. This is especially important in movement in the upright position, such as walking and climbing stairs. In addition, the degree of body sway is an indicator of instability when a person is performing motions in the upright position[1)]. A lesser degree of body sway is determined as higher stability. On the other hand, a greater degree of body sway is observed with an increase in age, stroke, and ankle sprain[2–4)]. The degree of body sway is considered to relate to a person's vision, hearing, and central nervous system/power output system, as well as one's psychological and emotional load[5)]. Muscle strength is considered to be a main factor of the power output system, and various studies have been carried out focusing on the correlation with individual muscles. In addition, the triceps surae is an anti-gravity muscle and is thought to be related to degree of body sway. Patterson et al.[6)] and Warnica et al.[7)] stated that loss of ankle plantar flexion strength (hereinafter "APFM strength") and fatigue increase the degree of body sway. In previous studies, large equipment, such as BIODEX and stabilograph (hereinafter "large equipment") were used to study the correlation between APFM strength and degree of body sway. While these have the advantage of higher reliability in data measurement, they also have the disadvantage of being unsuitable for portability. On the other hand, the authors used a handheld dynamometer (hereinafter "HHD"), and Body Pressure Measurement System (hereinafter "BPMS") to measure APFM strength and degree of body sway. These devices are easy to carry, easy to use, and at the same time, have been reported to provide reliable data which does not greatly differ compared to that by large equipment[8, 9)].

During physical therapy, there are various scenes where exercises are implemented for patients who have difficulty going up and down stairs or walking. In order to obtain and improve motions such as walking in such cases, the physical therapist plays a major role in reducing the degree of body sway. Consequently, carrying out an evaluation is very important. In addi-

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tion, smaller devices, such as HHD and BPMS, require little energy to carry and handle, and can be used in various places and scenes for measurement of persons who have difficulty walking. However, studies which measure APFM strength and degree of body sway using small devices, and which consider the correlation of these factors, could not be found. Consequently, the purpose of this study is to consider the correlation between APFM strength and degree of body sway, after measured them by using small equipment such as HHD and BPMS.

PARTICIPANTS AND METHODS

Twenty one healthy adult males with no leg problems (average age 20.5 ± 3.6 years old, average weight 65.3 ± 8.7 kg) were targeted. The objectives of the study, how the results would be processed, and anonymity at the presentation site and during presentation of the study results were fully explained to the students in advance. Next, persons who gave consent to the study were set as subjects. In addition, this study was carried out with the approval of the ethical committee of Fukuoka Wajiro Professional Training College (Approval No. FW-21-02).

APFM strength was measured using HHD (μTas F-1: Anima Co., Ltd., Tokyo, Japan). Regarding body position, sitting lengthwise on a mat and for knee extension position, plantarflexor/dorsiflexor strength were set at 0 degrees. Muscle strength to weight ratio (N/kg) of the dominant foot was measured. The HHD sensor was placed at the upper end of the metatarsophalangeal joint with the wall. In addition, the physical therapist manually fixed the ankle joint to prevent the heel from leaving the mat. In this condition, isometric contraction was encouraged for about 3 seconds at maximum effort. APFM strength was measured three times and average value was calculated. A 30 second break was taken between each operation.

Regarding degree of body sway, total trajectory length (cm) and outer peripheral area (cm^2) of a dominant foot were calculated according foot pressure central distribution data using BPMS (Nitta Corp., Osaka, Japan). Body position at measurement was set as standing on one leg with eyes open and bare feet, and the thigh and knee joints were set to be in the slightly bent position. Moreover, both upper limbs were lightly attached to the body side, and a point at the same height as the line of sight 2 m ahead was gazed. The time to stand on one leg was set as 30 seconds, and each side was performed twice, with the value with the least sway used as the representative value. A 30 second break was taken between each operation. Furthermore, regarding measurement methods for APFM strength and degree of body sway, previous studies were consulted[10, 11].

For statistical analysis, correlation between APFM strength and degree of body sway was considered by using Spearman's rank-correlation coefficient. Furthermore, SPSS Statistics V26.0 (IBM Japan Ltd, Tokyo, Japan) was used for statistical analysis, and significant difference was set at 5%.

RESULTS

As a result of measurements using HHD, APFM strength was 3.8 ± 0.7 N/kg. In addition, as a result of measurement using BPMS, total trajectory length was 71.4 ± 21.9 cm, and the outer peripheral area was 3.1 ± 1.4 cm^2 (Table 1). As a result of consideration of the correlation between APFM strength and degree of body sway, a negative correlation was observed ($p<0.05$, Table 2).

DISCUSSION

This study considered the correlation between APFM strength and degree of body sway. As a result, a negative correlation between plantar flexor muscle and degree of body sway was observed. The triceps surae is an anti-gravity muscle and is known to be related to the degree of body sway[12]. When a person takes standing position, the center of gravity shifts. To reduce sway on the sagittal plane, movement of anti-gravity muscles is essential, and there is a large correlation with the

Table 1. Measurement results of ankle plantar flexion strength and degree of body sway

Ankle plantar flexion strength (N/kg)	3.8 ± 0.7
Total trajectory length (cm)	71.4 ± 21.9
Outer peripheral area (cm^2)	3.1 ± 1.4

Mean ± standard deviation.

Table 2. Correlation between ankle plantar flexion strength and degree of body sway

	Ankle plantar flexion strength (N/kg)
Total trajectory length (cm)	−0.41*
Outer peripheral area (cm^2)	−0.55*

*$p<0.05$.

triceps surae[6, 12]. This is considered to result in a negative correlation between plantar flexor muscle and degree of body sway. From the results of this study, a correlation between APFM strength and degree of body sway, as described in previous studies, could be identified. As the same results as those using large equipment could be obtained, even when using small devices, such as HHD and BPMS, these results are considered to be meaningful.

As an advantage to being able to measuring APFM strength and degree of body sway using small devices which are easy to carry and handle is a wider field for physical therapists. In addition, in order to carry out accurate physical therapy, an accurate physical therapy evaluation is essential. However, large equipment is generally installed only in hospitals and is difficult to carry. Not only the patients who are in the hospital, but also young people such as junior high and high school students who regularly visit a local clinic and hospital in the region can also be targeted for physical therapy[13]. For young people, including junior high and high school students, epiphyseal cartilage and joint cartilage are still underdeveloped compared to adults, and are more likely to experience a sports injury or disability[14]. Takasawa reports that bone and joint disorders require the most caution in young people who are in the growing phase[14]. Moreover, when considering training of young people through sports and the development of sports rehabilitation, sports disabilities is the region in which physical therapists should be actively be involved. As an epidemiological study on sports disabilities. leg bone fractures and sprains are the most frequent injuries at 16.1%[15]. In foot injuries, disuse syndrome due to pain and rest causes a reduction in muscle strength around the ankle joint, and as a result, increased body sway can be predicted[16]. Hence, for early return to sports and accident prevention, positive intervention by the physical therapist is needed[17]. Cleland et al.[17] states that in cases of foot sprain, positive intervention by the physical therapist leads to a better prognosis. In addition, by taking small devices which are easier to carry to the local regions and clinics, APFM strength and degree of body sway can be measured in various places. As a result, accurate physical therapy may be implemented for more people. As a specific physical therapy method, muscle training within the range where pain is not felt is needed. Moreover, visually showing the change in APFM strength and the degree of body sway before and after intervention is thought to connect to improved goal setting and motivation by the participants. Luzio et al.[18] stated that visual feedback increases treatment effect.

As a limitation to this study, the fact that healthy adult males were targeted can be raised. Since muscle strength differs between males and females[19], correlation with body sway can also differ. In addition, many patients who receive physical therapy are elderly. As people age, muscular tension decreases, and the morphological characteristics of the muscles also change[20]. Hence in the future, clarification of the correlation between APFM strength and the degree of body sway in healthy adult females and elderly persons using the same method is desired.

Conflicts of interest

None.

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