J. Phys. Ther. Sci. 32: 554–556, 2020

The Journal of Physical Therapy Science

Original Article

Laterality of toe grip strength in Kendo players

Satoshi Inaba, MS, RPT[1)*], Ikuhiro Morikita, PhD, MD[1, 2)]

[1)] *Osaka University of Health and Sport Sciences Clinic: 1-1 Asasirodai, Kumatorichou, Sennangun, Osakafu, Osakashi 590-0496, Japan*
[2)] *Osaka University of Health and Sport Sciences, Japan*

Abstract. [Purpose] The purpose of this study was to determine whether unilateral dominance exists in toe grip strength in Kendo players using a toe grip dynamometer. [Participants and Methods] In total, 15 male college Kendo players, who had no disability or pain in their feet, were included in the study. The participants completed a questionnaire to determine which foot the participants used as their front and rear foot while standing in Kendo. We measured toe grip strength three times on each side. We then extracted the maximum value of toe grip strength from the three measurements on each side and calculated the ratio of toe grip strength to body weight (%). [Results] All players used their right foot as the front foot. We found that the front foot toe grip strength was significantly stronger than the rear foot toe grip strength. [Conclusion] Our results suggest laterality of toe grip strength and the front foot toe grip strength is stronger than the rear foot toe grip strength in Kendo players.

Key words: Toe grip strength, Laterality, Kendo

(This article was submitted Apr. 15, 2020, and was accepted Jun. 3, 2020)

INTRODUCTION

In the standing position, the feet and toes are the only body parts that touch the ground. Therefore, the tactile sensation of the toes and sole of the foot plays an important role in postural control[1)]. The foot and toes are important to movement; especially movement of the toes is related to posture, dynamic stability, and fall prevention[1–3)]. Toe-grip strength (TGS) is a method to evaluate the function of the toe. TGS is an index that reflects the flexion strength of the first to fifth toes and expressed as a force of grasping the ground with a toe during a movement made while playing a sport. In the clinic, it is common to perform towel-gathering exercises to enhance TGS. Uritani et al.[4)] measured TGS and found a significant correlation between age, body weight, and height. Soma et al.[5)] indicated the relationship between TGS increase and the Functional Reach Test; maximum step length; and improvement in walking ability. In recent years, there have been several studies on TGS[6–10)]. However, most of these were conducted involving healthy adults and the elderly, and there have been few reports of TGS in athletes. One study of TGS in athletes included a survey of the history of TGS and trauma among high school rugby players[11)]. Another report showed that TGS training interventions reduced the occurrence of ankle sprains in college soccer players[12)]. In a past study, we examined the superiority of TGS on one side on batting behavior in high school baseball players, and we found that TGS demonstrated one-sided superiority[13)]. These reports have helped assess TGS in athletes.

TGS did not show a one-sided advantage in normal healthy adults[14, 15)]. However, TGS showed a one-sided advantage in athletes[13)]. Oda[16)] reported that in sports events, muscle output often involves unilateral muscle contraction that predominates in the left or right unilateral muscle, and it is possible that TGS may be affected by competitions characteristics.

There is a unique Kendo striking motion. Front foot (FF) and rear foot (RF) are always the same leg during this unique Kendo striking motion in competitions. Therefore, it is conceivable that FF and RF always play different roles.

In this study, we measured TGS in university Kendo players, compared the stepping foot with the kicking leg, and examined whether there was one-sided advantage or not.

*Corresponding author. Satoshi Inaba (E-mail: e-3104@ouhs.ac.jp)

PARTICIPANTS AND METHODS

The participants included 15 male college Kendo players (15 male; mean ± standard deviation [SD]: age 18 ± 0 years, height 170.8 ± 6.3 cm, and body weight 71.5 ± 11.4 kg) who had no disability or pain in their feet. Measurements were performed immediately after admission to the study. The participants were well informed both orally and in writing and provided written informed consent. This study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki and approved by the Ethics Committee at the Osaka University of Health and Sport Sciences, Osaka, Japan (Approval number: 16-12).

A questionnaire was conducted before measuring TGS. The questionnaire included questions relating to preparations of Kendo, and whether the participant used either the left or right for the FF and RF.

We measured TGS using a T.K.K.3362 toe grip dynamometer (Takei Scientific Instruments, Japan). The participants sat upright on a chair without leaning on the backrest throughout the TGS measurement. Their hips and knees were flexed to 90°, and their ankles were placed in neutral position and fixed with a strap. The first proximal phalanx was positioned at the grip bar, and the heel stopper was adjusted to fit the heel of each participant. The bar was then gripped with maximal effort using the toes at maximal force for about 3 seconds. Testers stabilized the toe grip dynamometer during the measurements. TGS was measured three times on each side. The first toe to be measured was randomly selected and then the contralateral TGS was measured. After recording the maximum intensity on each side from three measurements of both sets of feet, the maximum TGS/body weight ratio (TGS/weight (%)), FF-TGS/weight (%) and RF-TGS/weight (%) were calculated.

Mean and SD values were calculated for descriptive data from each measurement. The calculated FF-TGS/weight (%) and BF-TGS/weight (%) were compared with a paired t-test. The significance level was set to 5%. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0.

RESULTS

The results of the questionnaire revealed that all 15 athletes used the right FF and none used the left FF. The difference between FF-TGS/weight (%) and RF-TGS/weight (%) in the 15 participants was significant ($p<0.01$). The effect size was $d=1.03$, and FF-TGS/weight (%) was significantly stronger compared with RF-TGS/weight (%) (Table 1).

DISCUSSION

In this study, we measured TGS in university student Kendo players and evaluated if TGS had one-sided superiority in Kendo competition. Athletes with higher body weights may show higher TGS values[4]. Therefore, we conducted a comparative study that used the percentage of body weight to eliminate this effect. As a result, it became clear that FF-TGS/weight (%) in Kendo players was significantly stronger than RF-TGS/weight (%). The basic stance in Kendo was to have the right foot as the FF, and all participants had the right foot in FF.

The FF-TGS/weight (%) was significantly stronger than RF-TGS/weight (%). This may be related to the competitive characteristics of Kendo. Nishitani et al.[17] reported on the floor reaction force during striking operation. They compared the peak values of the vertical and horizontal components of floor reaction force during striking operation with FF and RF, and found higher values in FF compared with RF. They also found that, in boys, the FF was about seven times larger than the RF, even if the composite force of the floor reaction force was observed. Based on these findings, the impact operation load is larger in FF, because the stepping foot function is important in FF, and the kick leg function is important in RF. In addition, in FF, the striking motion is similar to the motion from the time before the initial contact of the running motion to the early stage of standing, and the RF is similar to the motion of the foot-off. Mann et al.[18] examined the muscle activity of the lower limb during running using electromyography and found that muscles involved in TGS were active from before the initial touchdown to mid-stance. In other words, the TGS muscle activity was recognized during the Kendo hitting operation before FF depressed and touched down, and the FF-TGS activity was high during hitting operation.

Based on these findings, the FF-TGS activity with a large load resulting from the impact operation increased with the floor reaction force, and the TGS activity was higher than the RF. Therefore, when performing Kendo, it was important that

Table 1. Comparison of front foot and rear foot by toe grip strength and toe grip strength/body weight (n=15)

	FF	RF	Mean difference (95% CI)	
TGS (kg)	26.35 ± 3.98	23.59 ± 3.47	2.76 (1.29 to 4.23)	**
TGS/Wt (%)	37.42 ± 6.49	33.60 ± 6.32	3.82 (1.85 to 5.79)	**

Mean ± SD.
TGS: toe grip strength; TGS/Wt: toe grip strength/body weight; FF: front foot; RF: rear foot.
**$p<0.01$.

FF-TGS was stronger than RF-TGS. We found that FF-TGS/weight (%) was significantly higher. This result accords with previous studies of competitive characteristics of Kendo. Nishitani et al.[17] and Inoue et al.[19] evaluated the knee extension muscle strength in Kendo players and reported that right knee extension muscle strength tended to be higher compared with the left knee extension muscle strength. In addition, the findings of Kabe et al.[6] agree with previous studies about the dynamic posture control ability of TGS. They reported that a strong TGS had a small foot-to-foot ratio foot pressure center distance of dynamic posture control ability. Murata et al.[20] found that TGS was highly correlated with one-leg retention time. Therefore, FF-TGS/weight (%) was involved in the ability to perform a stable striking motion in Kendo competitions. On the other hand, studies[14, 15] have found no unilateral advantage for TGS. However, participants in these studies were healthy individuals, not athletes. Similar to this study, the definition of one side of the one-sided advantage was not based on the game characteristics. Instead, one-advantage was defined as one that uses the left-right difference or the foot kicking the ball and the opposite side.

We found that in Kendo players, TGS exhibited significant laterality in the FF, indicating that TGS demonstrated one-sided superiority. This result may indicate that the game characteristics of Kendo influenced the toe grip strength.

Funding and Conflict of interest

The authors declare no conflicts of interest, and that no funding was received.

ACKNOWLEDGEMENT

The authors would like to thank the participants who cooperated with this research and everyone who contributed to the data collection.

REFERENCES

1) Eils E, Behrens S, Mers O, et al.: Reduced plantar sensation causes a cautious walking pattern. Gait Posture, 2004, 20: 54–60. [Medline] [CrossRef]
2) Hughes J, Clark P, Klenerman L: The importance of the toes in walking. J Bone Joint Surg Br, 1990, 72: 245–251. [Medline] [CrossRef]
3) Mann RA, Hagy JL: The function of the toes in walking, jogging and running. Clin Orthop Relat Res, 1979, (142): 24–29. [Medline]
4) Uritani D, Fukumoto T, Matsumoto D, et al.: Reference values for toe grip strength among Japanese adults aged 20 to 79 years: a cross-sectional study. J Foot Ankle Res, 2014, 7: 28. [Medline] [CrossRef]
5) Soma M, Igarashi T, Kudou W, et al.: Influence of foot-gripping strength training to Functional Reach Test and maximal step length, walking ability in healthy adults. Jpn J Health Promot Phys Ther, 2012, 2: 59–63. [CrossRef]
6) Kabe N, Kurosawa K, Nishida Y, et al.: The study of relationship between toe and dynamic postural control. Rigakuryoho Kagaku, 2002, 17: 199–204. [CrossRef]
7) Handa S, Horiuchi K, Aoki K: A study measurement of toes grasping strength and effect of standing postural control. Ningenkougaku, 2004, 40: 139–147.
8) Fukuyama K, Osanai M, Maruyama H: Adult toe contact and the function of flooting toes. Rigakuryoho Kagaku, 2009, 24: 683–687. [CrossRef]
9) Takei K, Murata S, Kai Y: The relationship between toe function and static/dynamic balance: evaluation of content validity. W Kyushu J Rehabil Sci, 2009, 2: 13–19.
10) Yamauchi J, Koike H, Koyama K: Relations between ankle joint and toe grip force. The Japan Society of Mechanical Engineers, 2013, 216–217.
11) Oishi T, Nakano K, Otsuka S, et al.: The relationship between foot fingers grip strength and injury history in high school rugby union players. Teikyo Univ Sci Bull, 2012, 8: 157–162.
12) Fujitaka K, Fujitake S, Kita T, et al.: The effect of the foot arch related muscle strength training on the incidence of ankle and foot injuries in male college soccer players. Rigakuryoho Kagaku, 2012, 27: 263–267. [CrossRef]
13) Tanaka S, Iwanaga K, Murata S: Laterality of the lower limbs during action. Jpn J Health Promot Phys Ther, 2012, 2: 69–72. [CrossRef]
14) Murata S, Kai Y, Tanaka S, et al.: Development of a strain gauge based foot-gripping force meter. Rigakuryoho Kagaku, 2006, 21: 363–367. [CrossRef]
15) Kai Y, Murata S, Tanaka S: Comparison of foot-gripping strength and quadriceps femoris muscle strength of the dominant foot. Rigakuryoho Kagaku, 2007, 22: 365–368. [CrossRef]
16) Oda S: Right and left in body movement: mechanism of motion control in muscle output. Kyoto: Kyoto University Academic Press, 2006, pp 8–9.
17) Nishitani K, Masaoka T, Kokubu K, et al.: Characteristics of batting action in Kendo players viewed from floor reaction force, leg muscle strength, competitive ability. Sports Train Sci, 2005, 6: 5–13.
18) Mann RA, Moran GT, Dougherty SE: Comparative electromyography of the lower extremity in jogging, running, and sprinting. Am J Sports Med, 1986, 14: 501–510. [Medline] [CrossRef]
19) Inoue T, Makita M, Iwakiri K, et al.: Isokinetic leg extension power of Kendo players; in relation to competitive ability and laterality. Int Budo Univ Bull, 1994, 9: 27–32.
20) Murata S, Oyama M, Otao H: Relationship between one-leg standing time with eyes open and physical function among community-dwelling elderly females. Rigakuryoho Kagaku, 2008, 23: 79–83. [CrossRef]