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Effects of Landing Instructions on Achilles Tendon Load: Emphasizing Hip Flexion as the Optimal Strategy

ABSTRACT

Purpose: Managing Achilles tendon (AT) load during dynamic activities is essential for preventing and rehabilitating Achilles tendinopathy. While various exercises have been studied, the impact of verbal instructions on landing mechanics remains unclear. This study aimed to identify instructional methods that effectively reduce AT load during drop vertical jumps (DVJs).

Methods: Twenty-three healthy participants performed DVJs under five instructional conditions: 1) natural: no instruction; 2) posterior-COP: shifting the centre of pressure (COP) posteriorly; 3) hip-flexion: increasing hip flexion; 4) knee-flexion: increasing knee flexion; and 5) quiet-landing: minimising landing sound. A three-dimensional motion analysis system recorded peak AT force, loading rate, joint angles, ground reaction force (GRF), and COP position. Data were analysed using the Friedman test, Wilcoxon signed-rank test with Holm's correction, and effect size (ES).

Results: Peak AT force was significantly lower in hip-flexion and posterior-COP compared to natural ($P < 0.001$, ES = -0.87 and -0.82, respectively). Hip-flexion also showed lower AT force than the knee-flexion and quiet-landing ($P < 0.01$). Loading rates were lower in hip-flexion (ES = -0.73) and quiet-landing (ES = -0.64) than in natural ($P < 0.01$) but were higher in posterior-COP than hip-flexion ($P = 0.042$). Hip-flexion, knee-flexion, and quiet-landing increased hip flexion ($P < 0.001$), while knee-flexion and quiet-landing increased knee flexion ($P < 0.001$) compared to natural. Posterior-COP resulted in decreased hip, knee, and ankle flexion, increased vertical GRF, and a more posterior COP position compared to the other conditions ($P < 0.05$). Vertical GRF was lower in hip-flexion, knee-flexion, and quiet-landing than in natural ($P < 0.005$).

Conclusions: Increasing hip flexion is the most effective strategy for reducing AT force during landing, and may aid in the prevention and rehabilitation of Achilles tendinopathy. Although a posterior COP shift lowers AT force, it increases AT loading rate and GRF, potentially elevating injury risk.

Level of Evidence: Level III

Keywords: *Achilles tendinopathy, tendon injury, rehabilitation, landing, kinematics, motion analysis*

INTRODUCTION

The Achilles tendon (AT) is subjected to high loading levels during physical activity. For example, during running, double-leg jumps, or landings, the AT experiences forces exceeding three to four times body weight [4, 11, 34]. Although Achilles tendinopathy is multifactorial, cumulative exposure to high-magnitude loading cycles may serve as a mechanical risk factor for the condition, which commonly affects athletes in running and jumping sports [16]. When the magnitude and frequency of these loads exceed the tendon's capacity for adaptation and repair, particularly in the context of training-load escalation, poor recovery, metabolic factors, or ageing, maladaptive remodeling may occur, increasing the risk of symptomatic tendinopathy [10, 37].

Achilles tendinopathy is widespread and not limited to sports settings. In the general adult population, the annual incidence is 2.4 cases per 1,000 adults, with a prevalence of approximately 6% among physically active individuals [8, 38]. Additionally, the incidence has been reported at 19.7% in basketball, 4.9% in football, and 7.9% in futsal [16]. Once symptomatic, the condition often requires several months for recovery and has a 27% recurrence rate among elite athletes [17, 29]. The high incidence across sports, prolonged recovery periods, and elevated recurrence rates emphasise the need for prevention strategies.

Currently, no well-established methods exist for preventing Achilles tendinopathy; however, early recognition of symptoms and training-load management play essential roles in risk reduction [37]. To effectively control AT loading, it is important to understand which movement types and patterns impose high loads and loading rates on the tendon, as both factors may contribute to injury [1, 32]. Previous studies have quantified AT loading across various movement types, showing that AT loads vary by movement type and that drop jumps, running, and hopping generate particularly high loads [4, 11, 34]. These findings demonstrate the importance of selecting appropriate movement types in both preventive and rehabilitative interventions aimed at managing AT load. However, the optimal movement patterns for such purposes remain unclear.

Regarding movement patterns, a forefoot strike pattern during running has been shown to increase AT loading compared to a rearfoot strike pattern [40], indicating that transitioning to a rearfoot strike may reduce tendon load [32]. Similarly, during jump landings, hip and knee flexion angles, ground reaction force (GRF) magnitude, and centre of pressure (COP) position have been linked to AT loading [23]. However, it remains unclear whether modifying lower-limb movement patterns or GRF variables during landing effectively alters AT loading. If AT load can be reduced through changes in landing mechanics, such adjustments could serve as an effective preventive measure for

Achilles tendinopathy. Additionally, such insights would provide valuable information for designing rehabilitation programs based on AT loading.

Verbal instructions have been successfully used to modify landing mechanics in a simple and effective manner. For instance, instructing individuals to lean the trunk forward has been shown to reduce loading on both the AT and patellar tendon during landing [2, 35]. Similarly, providing instructions for lower-limb joint motion during landing has led to significant changes in lower-limb kinematics and GRF variables [13]. However, to our knowledge, no studies have examined whether verbal instructions targeting lower-limb kinematics or GRF influence AT loading during landing.

This study investigated how verbal instructions targeting lower-limb joint motion, GRF, and COP position influence AT loading and loading rate during landing. Based on previous findings [23], we hypothesized that AT loading would decrease following instructions to increase hip and knee flexion, to perform a quiet landing to reduce GRF, and to shift the COP posteriorly.

METHODS

A power analysis was conducted using a repeated-measures ANOVA model in G*Power 3.1 (University of Düsseldorf, Germany) to determine the required sample size [14]. The effect size was set to moderate ($f = 0.25$), with a significance level of 0.05 and a power of 0.8, indicating a minimum sample size of 21 participants. The moderate effect size ($f = 0.25$; approximately equivalent to Cohen's $d \approx 0.50$) was chosen, as this magnitude is widely recognized as a distribution-based estimate of the minimal clinically important difference [30, 31]. A total of 23 healthy university students (12 males, 11 females; age: 21.4 (2.3) years, height: 164.5 (7.9) cm, mass: 58.4 (7.0) kg) recruited from our university were included in the study. Participants were required to have a history of regular participation in sports, such as basketball, volleyball, or soccer. Exclusion criteria included a history of lower extremity fracture or surgery and any musculoskeletal injury within the past 6 months. This study was approved by the university's institutional review board (No. 23-78-1), and all participants provided informed consent.

Participants first completed a 5-minute warm-up on a stationary bicycle at a self-selected pace. Reflective markers were then attached to key anatomical landmarks of the pelvis and lower extremities, including the iliac crests, anterior and posterior superior iliac spines, medial and lateral femoral epicondyles, medial and lateral malleoli, first, second, and fifth metatarsal heads, navicular tuberosity, and heel [20, 24]. Additionally, marker clusters were placed

on the lateral surfaces of the thighs and shanks [20, 24].

A static trial was recorded with participants in a bipedal standing position, with their feet pointing straight ahead and their hips in a neutral adduction-abduction position. Participants then performed a drop vertical jump (DVJ) task, stepping forward off a 30-cm high box and immediately executing a maximum vertical jump upon landing. This task was recorded using a 3D motion analysis system (Cortex software version 5.5, Motion Analysis Corp., USA) comprising seven digital cameras (Hawk cameras, Motion Analysis Corp.) and two force plates (Type 9286, Kistler AG, Switzerland) positioned in front of a 30-cm high box (Fig. 1), with sampling rates of 200 Hz and 1000 Hz, respectively.

Five different landing conditions were assessed (Fig. 1): 1) a natural landing (no instruction), 2) posterior-COP (instruction to shift plantar load position as far posteriorly as possible toward the heel during landing, 3) hip-flexion (instruction to increase hip flexion), 4) knee-flexion (instruction to increase knee flexion), and 5) quiet-landing (instruction to minimise landing sound). Under all conditions, participants were instructed to jump as quickly and as high as possible. The natural condition was performed first, followed by the remaining four instruction conditions in a randomised order using a function in Microsoft Excel (Microsoft Corp., USA). Participants practised each condition until they were familiar with the movements, and three successful trials were recorded for each condition.

The recorded marker coordinate data were filtered using a fourth-order Butterworth low-pass filter at 12 Hz, while the GRF data were low-pass filtered at 50 Hz. Lower limb joint angles and moments, GRF data, and COP positions were calculated using Visual 3D software (HAS-Motion, Inc., Canada). The hip centre was determined according to Bell et al. [5], the knee joint centre was defined as the midpoint between the medial and lateral epicondyles, and the ankle joint centre was defined as the midpoint between the medial and lateral malleoli. Joint angles were calculated using a joint coordinate system with an *X-Y-Z* Cardan sequence, and only sagittal plane angles associated with AT force were analysed in this study [23]. Body segment parameters were based on deLeva's data [9] and ankle plantar flexion moments were computed.

Based on previous studies [23, 32, 36], AT force was calculated by dividing the internal ankle plantar flexion moment by the AT moment arm. The AT moment arm was estimated using a regression equation derived from MRI data as a function of ankle flexion angle in the sagittal plane (θ) [33]:

$$\text{Achilles tendon moment arm} = -0.591 + 0.08297\theta - 0.0002606\theta^2$$

The peak AT force during the first landing phase was identified, with the first landing phase defined as the

period from the initial contact to toe-off. Initial contact and toe-off during DVJ were determined as the moment when vertical GRF exceeded or fell below 10 N [3, 21]. The AT loading rate was calculated as the change in the AT force from initial contact to the peak value, divided by the time to reach peak force [26].

Joint angles, COP positions, and vertical GRF values were extracted at the moment of peak AT forces. Peak vertical GRF during the landing phase was also extracted. Both AT force and vertical GRF were normalised to each participant's body weight. Data reductions and all calculations were performed using MATLAB 2021b (MathWorks Inc., Natick, MA, USA). COP position was defined as the anteroposterior distance from the second metatarsal head marker and standardised by dividing it by foot length (the distance between the second metatarsal head and the heel markers).

To assess the impact of landing instruction conditions on DVJ performance, jump height, ground contact time, and reactive strength index were calculated. Jump height was defined as the difference between the maximum height of the pelvic centre of mass during the jump and its height during quiet standing, based on a previously established method [6, 18]. Ground contact time was defined as the duration between initial ground contact and toe-off. Reactive strength index was calculated by dividing the jump height by the ground contact time, reflecting the ability to rapidly generate force [22].

Normality was assessed using the Shapiro–Wilk test. As most variables were not normally distributed, the Friedman test was used to compare differences among the five landing conditions for peak AT force, AT loading rate, joint angles, GRF, and COP position. Post-hoc pairwise comparisons were conducted using the Wilcoxon signed-rank test with Holm's correction. Statistical analyses were performed using JMP Pro 17 (JMP Statistical Discovery LLC, USA) and Microsoft Excel (Microsoft Corporation, USA). The significance level was set at $p < 0.05$.

For peak AT force and loading rate, effect sizes (ESs) were calculated to quantify the differences between instructional conditions. The ESs were interpreted as small (≥ 0.1), moderate (≥ 0.3), large (≥ 0.5), very large (≥ 0.7), and extremely large (≥ 0.9) [19].

RESULTS

Peak AT force significantly differed among the five landing conditions ($P < 0.001$) (Fig. 2). All conditions showed a significant decrease in peak AT force compared to the natural condition (posterior-COP, $P < 0.001$; hip-flexion, $P < 0.001$; knee-flexion, $P = 0.007$; quiet-landing, $P = 0.004$). The ESs for the differences from the natural

condition were very large for the hip-flexion ($ES = -0.87$) and posterior-COP ($ES = -0.82$) conditions, and large for the knee-flexion ($ES = -0.62$) and quiet-landing ($ES = -0.65$) conditions. Additionally, the peak AT force in the hip-flexion condition was significantly lower than that in the knee-flexion ($P = 0.007$, $ES = -0.62$) and quiet-landing ($P < 0.001$, $ES = -0.70$) conditions. The posterior-COP condition had a significantly lower peak AT force than the quiet-landing condition ($P = 0.018$, $ES = -0.56$).

AT loading rate significantly differed across landing conditions ($P < 0.001$) (Fig. 2). The loading rates in the hip-flexion ($P < 0.001$, $ES = -0.73$) and quiet-landing ($P = 0.006$, $ES = -0.64$) conditions were significantly lower than in the natural condition, with the ESs ranging from large to very large. In contrast, the loading rate in the posterior-COP condition was significantly higher than that in the hip-flexion condition ($P = 0.042$, $ES = 0.55$).

Vertical GRF at peak AT force and peak vertical GRF differed significantly among the five conditions (GRF at peak AT: $P = 0.010$; peak GRF: $P < 0.001$) (Fig. 3). Vertical GRF at peak AT force was significantly lower in the hip-flexion, knee-flexion, and quiet-landing conditions compared to that in the natural condition (all $P < 0.001$). Conversely, the posterior-COP condition had a significantly higher vertical GRF at peak AT force than the hip-flexion ($P = 0.001$), knee-flexion ($P = 0.009$), and quiet-landing ($P = 0.004$) conditions. Similarly, peak vertical GRF was significantly lower in the hip-flexion ($P = 0.003$), knee-flexion ($P < 0.001$), and quiet-landing ($P < 0.001$) conditions compared to the natural condition (Fig. 2). The peak vertical GRF in the posterior-COP condition was significantly higher than that in all other conditions (natural: $P = 0.033$, others: $P < 0.001$).

Hip, knee, and ankle flexion angles varied significantly across landing instruction conditions (all $P < 0.001$) (Table 1). The hip flexion angle was significantly greater in the hip-flexion ($P < 0.001$), knee-flexion ($P < 0.001$), and quiet-landing ($P = 0.004$) conditions than in the natural condition. Additionally, the knee-flexion condition showed significantly greater hip flexion than the quiet-landing condition ($P = 0.003$). The hip flexion angle in the posterior-COP condition was significantly smaller than those in the hip-flexion, knee-flexion, and quiet-landing conditions (all $P < 0.001$).

The knee flexion angle was significantly greater in the knee-flexion condition than in the natural ($P < 0.001$) and quiet-landing ($P = 0.002$) conditions. The quiet-landing condition also had significantly greater knee flexion than the natural condition ($P = 0.026$). The knee flexion angle in the posterior-COP condition was significantly smaller than that in all the other conditions (natural: $P = 0.006$; others, $P < 0.001$). There was no significant difference in knee flexion between the hip-flexion and natural conditions ($P = 0.098$).

The ankle dorsiflexion angle was significantly smaller in the posterior-COP condition than in all other conditions (all $P < 0.001$). Additionally, COP position varied significantly across conditions ($P < 0.001$). The COP position was significantly more posterior in the posterior-COP condition to the natural ($P = 0.046$), knee-flexion ($P = 0.003$), and quiet-landing ($P = 0.005$) conditions (Table 1).

For DVJ performance, jump height, ground contact time, and reactive strength index significantly differed across the conditions (all $P < 0.001$) (Table 2). The jump height was significantly lower in the posterior-COP condition than in all other conditions (all $P < 0.001$). The ground contact time was significantly longer in the posterior-COP, hip-flexion, knee-flexion, and quiet-landing conditions than in the natural condition (all $P < 0.001$). The hip-flexion ($P < 0.001$) and knee-flexion ($P = 0.003$) conditions also had significantly longer ground contact time than the quiet-landing condition. The reactive strength index was significantly lower in the posterior-COP, hip-flexion, knee-flexion, and quiet-landing conditions than in the natural condition (all $P < 0.001$). Additionally, the posterior COP ($P = 0.008$), hip flexion ($P < 0.001$), and knee flexion ($P = 0.009$) conditions had significantly lower reactive strength index than the quiet-landing condition.

DISCUSSION

This study is the first to examine instructional methods for modifying AT loading during landing. Peak AT force was reduced under all instructed landing conditions (posterior-COP, hip-flexion, knee-flexion, and quiet-landing). Notably, the hip-flexion condition led to the most significant reduction in peak AT force, with a greater decrease compared to the knee-flexion and quiet-landing conditions. Additionally, the hip-flexion condition significantly lowered the AT loading rate. In contrast, while the posterior-COP condition effectively reduced peak AT force, it resulted in a significantly higher AT loading rate and GRF compared to the other conditions. These findings suggest that instructing individuals to increase hip flexion during landing is the most effective strategy for safely reducing AT load.

Landings that emphasise increased hip flexion significantly reduced peak AT force and loading rate. The present study used this landing instruction because decreased hip flexion has been associated with increased AT force during landing [23]. One possible explanation is that the hip-flexion conditions reduced GRF at the point of peak AT force. Since GRF is strongly associated with AT force [23], a reduction in GRF likely contributed to the observed decrease in AT force. However, a reduction in GRF was also observed in the knee-flexion and quiet-landing conditions.

Unlike these conditions, the hip-flexion condition increased hip flexion without increasing knee flexion. A previous study suggested that reduced hip flexion and increased knee flexion independently contribute to higher AT force [23]. The absorption of GRF primarily by the hip joint may have reduced the mechanical demand on the ankle joint [25], leading to a decrease in AT force. The hip-flexion condition demonstrated a very large ES for AT force reduction, indicating that it was the most effective landing instruction among those tested in this study. Moreover, increasing hip flexion during landing has also been associated with a reduced risk of knee ligament injuries [27], suggesting that it may serve as a practical and effective strategy for preventing lower extremity injuries.

Instructional conditions designed to reduce landing sound also reduced peak AT force and loading rate. This condition aimed to reduce GRF associated with increased AT load [23]. This condition decreased vertical GRF and increased knee flexion, which is consistent with findings from a previous study [39]. However, unlike in the previous study, it did not significantly alter the ankle angle [39]. This discrepancy may be attributed to differences in the number of comparison conditions or variations in the extraction time points for the analysed joint angles. Given its large effect on AT force reduction and its ability to lower vertical GRF, the quiet-landing condition was considered both safe and effective.

The posterior-COP condition, which was intended to shift the COP position posteriorly, significantly reduced AT force. This reduction was likely due to the posterior COP shift, which decreased the plantar flexion moment of the ankle. However, the AT loading rate in the posterior-COP condition was higher than that in the hip-flexion condition, and the peak vertical GRF was significantly greater than that in the other conditions. This may be explained by the limited ability of the posterior-COP condition to absorb GRF, as it resulted in reduced ankle dorsiflexion, knee flexion, and hip flexion compared to the other conditions. Increased GRF, combined with decreased lower-extremity joint flexion—characteristic of a stiff landing—has been associated with a higher risk of knee ligament injury [12, 28]. While posteriorly shifting the COP reduced peak AT force effectively, it may not be ideal for sports injury prevention, given its effects on AT loading rate, GRF, and lower limb kinematics.

Landing instructions emphasising increased knee flexion reduced peak AT force effectively. This instruction was selected because the knee flexion angle is associated with AT load. A previous study found that increased knee flexion was associated with higher AT force in multivariate analysis but lower AT force in univariate analysis [23]. In this study, instructions to increase knee flexion also resulted in a significant increase in hip flexion and a decrease in vertical GRF. The observed reduction in AT force in the knee-flexion condition may be attributed to increased hip

flexion and a reduction in GRF. However, because the knee condition had a smaller effect on reducing peak force compared to the hip condition and did not decrease the loading rate, the hip condition should be prioritized.

Instruction to increase hip flexion was effective in reducing AT load during landing, but also had a significant impact on DVJ performance. Compared to the natural condition, this instruction did not affect jump height but led to prolonged ground contact time and a reduced reactive strength index, indicating a temporary decrease in stretch-shortening cycle efficiency. Previous studies have shown that instructing athletes to perform soft landings or landings with increased knee flexion may help prevent ACL injuries [7, 15]; however, these techniques have also been associated with decreased jump height and increased ground contact time [7]. Similar to the previous study [7], the present study examined only the immediate effects of verbal instructions. Future studies should examine whether medium- to long-term repetitive practice using the hip-flexion instruction can simultaneously reduce AT load while maintaining performance during landing. During Achilles tendinopathy rehabilitation, where load management takes precedence over performance, the immediate effects of these instructions may offer clinical benefits.

From a clinical perspective, recognising minor symptoms and managing load is crucial for preventing Achilles tendinopathy [37]. This study suggests that instructing athletes to increase hip flexion during landing may be the most effective strategy for controlling AT loading. These findings also offer valuable insights for Achilles tendinopathy rehabilitation, as it involves AT loading and progressive exercise intensification. If AT loading is excessive and causes pain during jumping and landing exercises in rehabilitation, instructing patients to increase hip flexion may be beneficial. The findings of this study could inform exercise training strategies for both the prevention and rehabilitation of Achilles tendinopathy. Furthermore, these findings may also be applicable to exercise therapy following AT rupture.

This study has some limitations. First, it was conducted with healthy participants, which may limit its applicability to individuals with Achilles tendinopathy. Second, the study did not examine the effects of forward trunk lean. Recent evidence suggests that forward trunk leaning during single-leg landing effectively reduces AT force [2]. Future studies should include a forward trunk leaning condition in the instructional protocols and compare the outcomes. Third, although landing instructions may reduce AT forces, it remains unclear whether they can prevent Achilles tendinopathy. Further research is needed to investigate the preventive effects of landing instructions.

250 **CONCLUSION**

251 Verbal landing instructions that increased hip flexion, increased knee flexion, reduced landing sound, and shifted the
252 COP posteriorly all significantly reduced peak AT force during landing. Among these, instructions that increased hip
253 flexion resulted in the most significant reduction in peak AT force and AT loading rate. In contrast, instructing
254 participants to position the COP more posteriorly reduced the peak AT force but led to an unsafe landing pattern,
255 characterised by an increased AT loading rate and stiff landing mechanics. The quiet landing condition also reduced
256 the AT loading rate. Based on these findings, increasing hip flexion should be prioritized as an effective strategy for
257 safely reducing AT load during landing, followed by reducing landing sound and then increasing knee flexion.

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FIGURE CAPTIONS

Fig. 1 Five instructional conditions were performed during the first landing of the DVJ

(A) Natural landing without instruction (natural condition), (B) Instruction to shift the COP posteriorly upon landing (posterior-COP condition), (C) Instruction to flex the hip joint significantly upon landing (hip-flexion condition), (D) Instruction to flex the knee joint significantly upon landing (knee-flexion condition), (E) Instruction to reduce landing sound (quiet-landing condition)

Fig. 2 Box plots of peak AT force (left) and AT loading rate (right) under five conditions

a indicates significant differences from the natural condition

b indicates significant differences from the quiet-landing condition

c indicates significant differences from the knee-flexion condition

d indicates significant differences from the posterior-COP condition

Fig. 3 Box plots of vertical GRF at peak AT force (left) and peak vertical GRF (right) under five conditions

a indicates significant differences from the natural condition

b indicates significant differences from the posterior-COP condition

386 **List of Abbreviations**

387 AT – Achilles Tendon

388 COP – Center of Pressure

389 DVJ – Drop Vertical Jump

390 GRF – Ground Reaction Force

1 **Table 1.** Median and interquartile range of joint angle and centre of pressure (COP) across five conditions

	Natural	Posterior-COP	Hip-flexion	Knee-flexion	Quiet-landing
Hip flexion (°)	47.7 (19.7)	42.1 (14.5)	65.7 (19.3) ^{ac}	67.2 (22.2) ^{abc}	57.1 (16.2) ^{ac}
Knee flexion (°)	72.2 (14.5)	56.8 (11.6) ^a	82.3 (30.0) ^c	93.9 (23.0) ^{abc}	82.7 (10.8) ^{ac}
Ankle dorsiflexion (°)	29.4 (9.9)	18.5 (9.6) ^a	27.1 (12.5) ^c	30.6 (11.1) ^c	29.0 (11.1) ^c
COP position (%)	-3.8 (5.7)	-15.5 (24.2) ^a	-4.0 (10.9)	-1.6 (8.6) ^c	-1.2 (7.1) ^c

2 All variables were measured at the peak Achilles tendon force. Positive values indicate hip flexion angle, knee flexion
3 angle, ankle dorsiflexion angle, and anterior COP position (relative to the second metatarsal head marker).

4 ^a significantly different from the natural condition.

5 ^b significantly different from the quiet-landing condition.

6 ^c significantly different from the posterior-COP condition.

1 **Table 2.** Median and interquartile range of performance measures across five conditions

	Natural	Posterior-COP	Hip-flexion	Knee-flexion	Quiet-landing
Jump height (cm)	33.3 (7.5) ^c	31.1 (6.4)	33.1 (10.6) ^c	35.6 (11.2) ^c	32.3 (9.6) ^c
Ground contact time (ms)	335.0 (81.7)	486.7 (184.2) ^a	531.7 (79.2) ^{ab}	521.7 (85.8) ^{ab}	476.7 (123.3) ^a
Reactive strength index (cm/ms)	101.8 (45.9)	71.1 (33.9) ^{ab}	66.7 (29.0) ^{ab}	69.1 (22.3) ^{ab}	74.1 (39.7) ^a

2 ^a significantly different from the natural condition.

3 ^b significantly different from the quiet-landing condition.

4 ^c significantly different from the posterior-COP condition.

Fig. 1

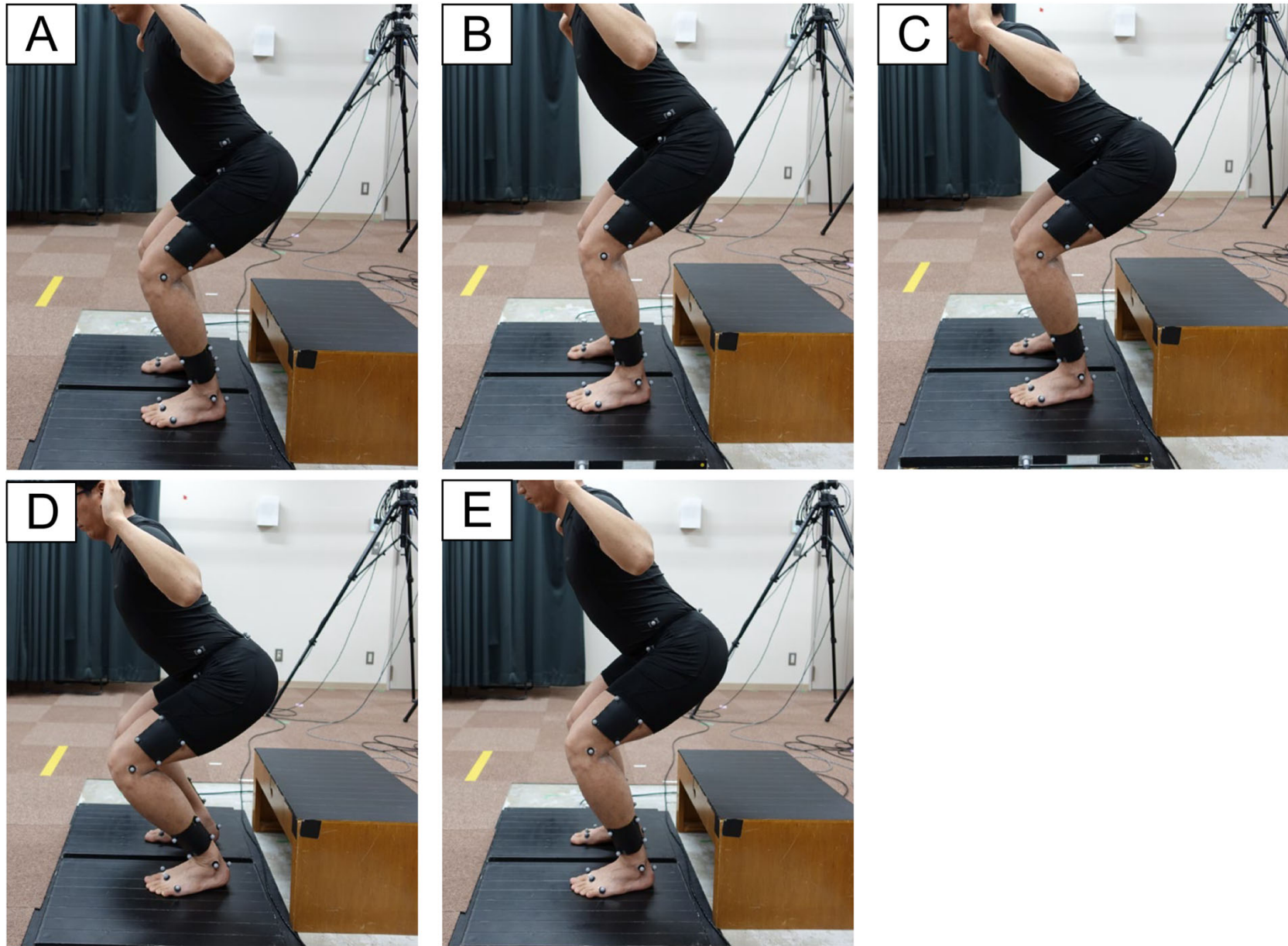


Fig. 2

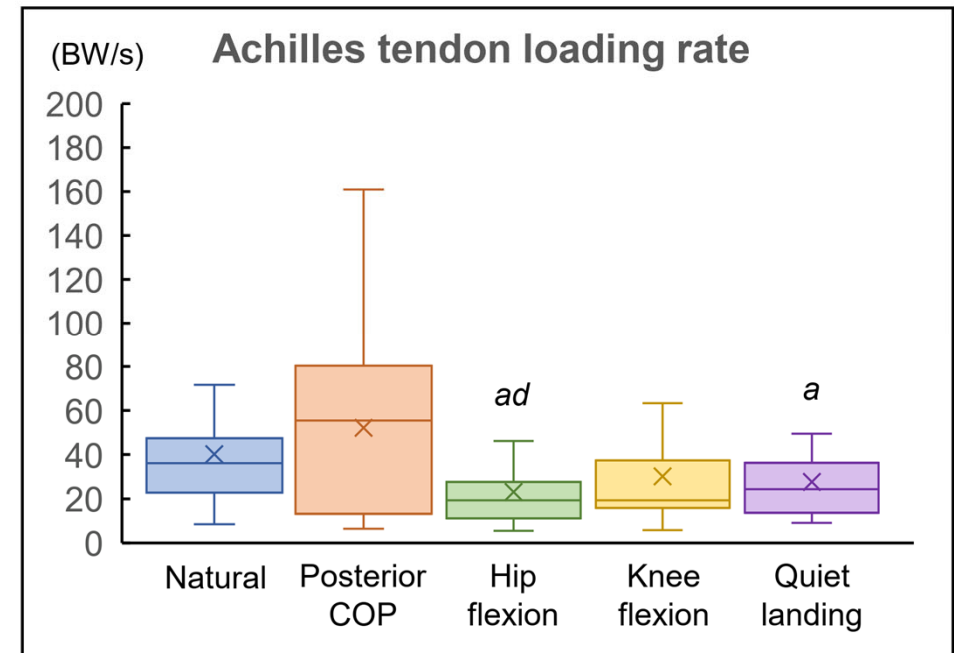
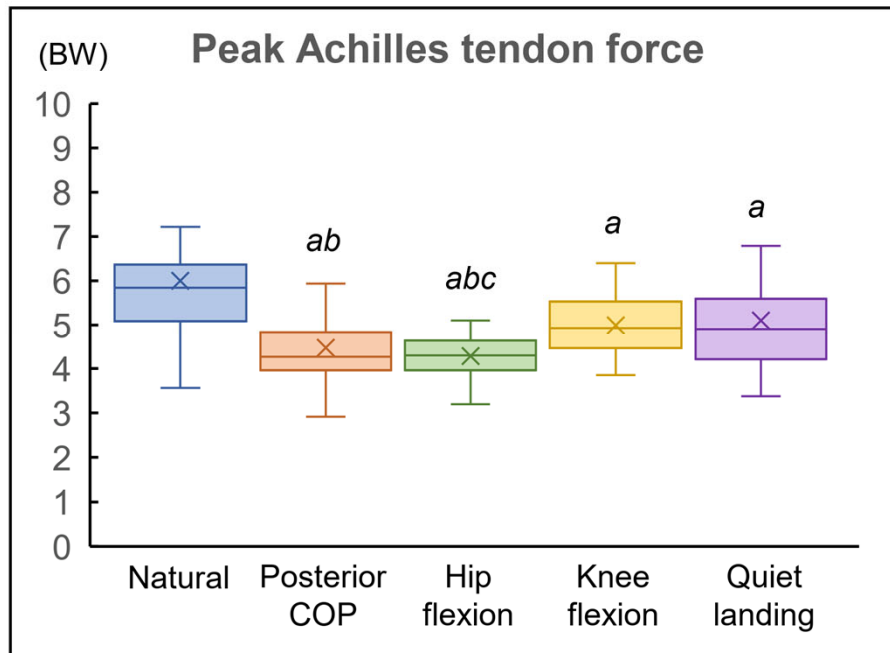


Fig. 3

