Muscle force profiles in the rat tibialis anterior as a function of various frequencies of eccentric muscle contraction

R. Oga[1], K. Nakagawa[1], K. Hayao[2], H. Tamaki[3]

[1] Graduate School of Physical Education, National Institute of Fitness and Sports in Kanoya, [2] Southern Tohoku General Hospital,
[3] Department of Sports and Life Science, National Institute of Fitness and Sports in Kanoya

INTRODUCTION

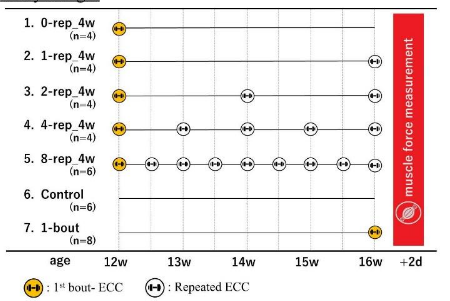
High-intensity eccentric contractions (ECC) cause muscle damage and result in muscle function deficits. According to previous reports, prior ECC-induced muscle damage reduces the severity of subsequent muscle-damage symptoms[1]. However, there remains a lack of understanding of the adaptations in muscle strength to the frequent performance of high-intensity ECC. We examined the effects of frequent ECC on the twitch and tetanic contraction forces in the rat tibialis anterior (TA).

METHODS

Animal:
- Thirty-two 12-week-old male Fischer 344 rats

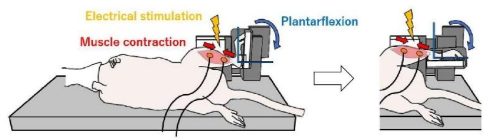
Muscle:
- Tibialis anterior (TA)

Study design:

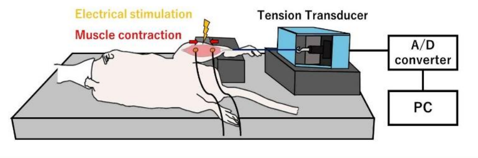


ECC-protocol[2]:
- Submaximal tetanic contraction for 2 s
- 8 sets × 10 contractions (every 10 s, 3 min intervals)
- Anglar velocity: 200 deg・s^{-1}

Electrical stimulation (ES)[2]:
- Intensity: 30 V
- Frequency: 100 Hz
- Pulse width: 500 μs



Muscle force measurement[3]:
- The distal tendon of the TA was attached to the tension transducer via suture
- Twitch and tetanic contraction forces and dP/dt by the ES of the TA were recorded on a PC via an A/D converter



RESULTS

- Max force, twitch force and dP/dt in the 1-bout group were significantly smaller than in the Cont group. (Fig 1A-C)
- Max force, twitch force and dP/dt decreased by approximately 40-60 %, 30-50 % and 20-40 %, respectively, as the number of repetition counts increased. (Fig 1D-F)
- Max force decreased exponentially (R^2 = 0.80) as the number of repetition counts increased. (Fig 2)

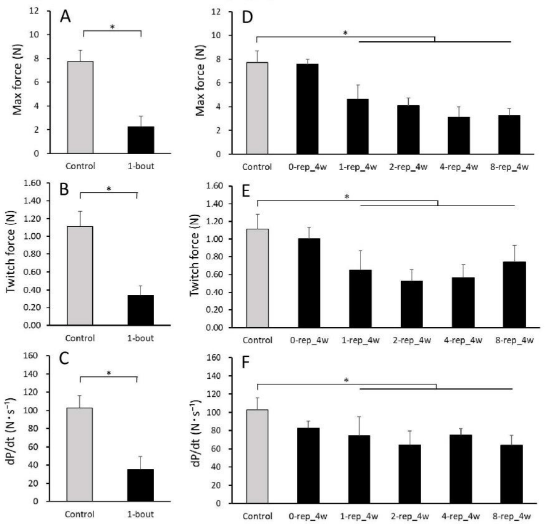


Fig1. Mean ± SD for each muscle force profiles. A, D: Max force, B, E:Twitch force, C, F: dP/dt (* p < 0.05 versus Control)

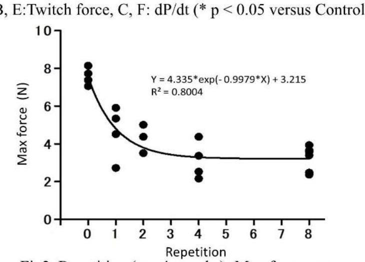


Fig2. Repetition (per 4- weeks)- Max force curve

CONCLUSION

These results suggest that a four-week ECC repetition intervention will reduce muscle contraction performance in the TA in accordance with the number of repetitions. Repeated high-intensity ECC interventions may reduce the force-generating capacity of the muscle fibers, resulting in an alteration in lower-limb muscle contractile properties.

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SPORT & SCIENCE ECSS ● PARIS 2023

Contact: m226003@sky.nifs-k.ac.jp (Ryoya OGA)

ISB・JSB FUKUOKA 2023

No.0974

Effect of the Upper Limb Joints on the Control of Ball Speed in Throwing Distance Control of Throw-in

Rintaro Miyake[1], Terumitsu Miyazaki[1], Shota Yamamoto[1] and Munenori Murata[2]

[1]National Institute of Fitness and Sports in Kanoya, Japan, [2]Toyo University, Japan

Introduction

- ✓ In soccer, the throw-in requires accurate throwing distance control depending on the variety of situations.
- ✓ Most previous studies on throw-in have focused on obtaining the maximum distance; however, the controlling of throwing distance has not been fully examined.
- ✓ A previous study focused on the basketball shot, which investigated an accurate throwing distance control, has reported that the upper limb kinematics changes with an increase in throwing distance (Ishikawa et al., 2020).

We hypothesized that the upper limb joint kinematics would also change to control the throwing distance in the throw-in.

Purpose

To examine **the effect of upper limb joint kinematics on controlling the ball speed in throwing distance control**

Conclusion

1. **The elbow joint contributed most to the controlling of throwing distance among the upper limb joints.**
2. **The shoulder joint would contribute to controlling the release angle to throw the ball at the optimal release angle.**

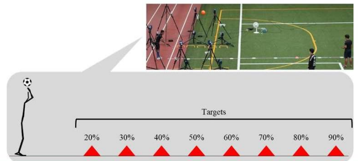
Methods

【Data Collection】

Five collegiate male soccer players (height: 172.7 ± 6.0cm, mass: 62.8 ± 4.3kg, age: 20.6 ± 1.4years) performed standing throw-in to the targets that were placed at every 10% relative distance to the maximum throwing distance for each participant.

【Data Analysis】

- ✓ The kinematic parameters of the body and ball at the release
- ✓ The generated ball speed (GS) at the release by each joint's angular velocity
- ✓ The conversion efficiency (CE) from the generated ball velocity by each joint's angular velocity to the actual ball speed at the release



【Generated Ball Speed Calculation】

$$GS = \hat{v}_{Ball} \cdot (\omega_{Joint} \times r_{Joint \to Ball})$$

GS is generated ball speed by each joint's angular velocity.
$\hat{v}_{Ball}$ is the unit vector of the ball velocity.
ω_{Joint} is the joint angular velocity.
$r_{Joint \to Ball}$ is the vector from the joint to the ball.

(Sprigings et al., 1994)

$$GS_{\hat{\omega}} = \hat{v}_{Ball} \cdot (\hat{\omega}_{Joint} \times r_{Joint \to Ball})$$

$GS_{\hat{\omega}}$ is generated ball speed per unit vector of angular velocity.
$\hat{\omega}_{Joint}$ is the unit vector of the joint angular velocity.

(Sprigings et al., 1994)

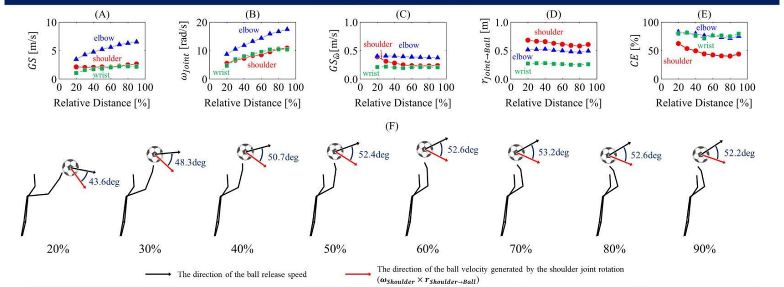
【Conversion Efficiency Calculation】

$$CE = \hat{v}_{Ball} \cdot (\hat{\omega}_{Joint} \times \hat{r}_{Joint \to Ball})$$

CE is conversion efficiency from the generated ball velocity by each joint's angular velocity to the actual ball speed.
$\hat{r}_{Joint \to Ball}$ is the unit vector from the joint to the ball.

※ The data in this presentation represent the mean of all participants.

Results & Discussion



【The elbow joint】

The GS of the elbow joint increased along with the throwing distance (Fig. A).

- ✓ The angular velocity of the elbow joint increased along with the throwing distance and was the largest among the upper limb joints in all throwing distance (Fig. B).
- ✓ The $GS_{\hat{\omega}}$ and CE of the elbow joint was constant in all throwing distance (Fig. C, E).

→ The distance from the elbow joint to the ball was unchanged in all throwing distance because of the absence of the wrist joint's range of motion (Fig. D).

The elbow joint was the main contributor to control of the throwing distance in the throw-in because the GS of the wrist and shoulder joints were almost constant (Fig. A).

【The wrist joint】

The GS of the wrist joint was almost constant in all throwing distance (Fig. A).

- ✓ The angular velocity of the wrist joint was smaller than the elbow joint at all throwing distance (Fig. B).
- ✓ The distance to the ball and the $GS_{\hat{\omega}}$ were smaller at the wrist joint compared with the other upper limb joints in all throwing distance (Fig. C, D).

The wrist joint was a smaller contribution to generating ball speed than the elbow joint.

【The shoulder joint】

The GS of the shoulder joint was almost constant in all throwing distance (Fig. A).

- ✓ The angular velocity of the shoulder joint increased along with the throwing distance (Fig. B).
- ✓ The ball is positioned forward to the shoulder joint at the release due to the regulation (IFAB, 2022). Therefore, the shoulder joint rotation generates the forward and downward ball velocity in all throwing distance (Fig. F).
- ✓ The $GS_{\hat{\omega}}$ and CE of the shoulder joint at 20% of the relative distance are the largest of all throwing distance (Fig. C, E).

→ The angle between the generated ball velocity by the shoulder joint rotation and the actual release velocity of the ball is smaller at 20% of the relative distance compared with the other relative distance because of throwing the ball toward the target with a straight trajectory (Fig. F).

- ✓ However, the $GS_{\hat{\omega}}$ and CE of the shoulder joint decreased with the increasing throwing distance (Fig. C, E).

→ The angle between the generated ball velocity by the shoulder rotation and the actual release velocity increased along with the release angle (Fig. F).

The role of the shoulder would decrease the ball's release angle to throw the ball with the optimal release angle because the generated ball velocity by the shoulder joint rotation was forward and downward in all throwing distance (Fig. F).

No corporate support was received for this research.

Investigating the reliability and validity of a rating scale for tennis service movements based on subjective evaluation

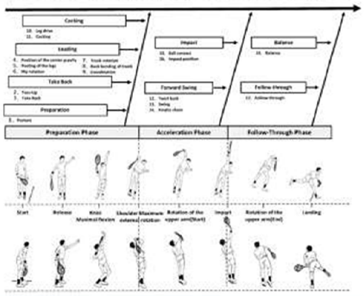
Keisuke Osawa [1], Daisuke Mitsuhashi [2], Hideki Takagi [2], Shunsuke Murakami [1], Hiroo Takahashi [1]

1. Faculty of Sports and Budo Coaching Studies, National Institute of Fitness and Sports in KANOYA, Kanoya, Japan
2. Institute of Health and Sport Sciences, University of Tsukuba, Japan,

ARIHHP

【Introduction & Method】

The purpose of this study was to establish criteria for observational evaluation of tennis service motions and to examine their reliability, objectivity, and validity. By referring previous studies, first, we extracted information on motions that were considered important when analyzing service motions from a biomechanical perspective, and then five tennis experts qualitatively analyzed the structure of service motions using characteristic factor analysis with the Delphi method and established evaluation items and their criteria. The reliability, objectivity, and validity of the developed criteria were examined in 61 university student tennis players (38 males and 23 females). The participants were required to hit a flat service from the deuce side to the center with maximum effort. Intra-observer reliability was analyzed based on the agreement between two evaluations by one of the researchers with the same data set, and Inter-observer reliability was analyzed based on the agreement between the evaluations of three tennis experts. The validity was examined by classifying the subjects into two groups: one with Superior Motion Group (SG) and the other with Inferior Motion Group (IG), and by examining the differences between the two groups on each of the assessment items.



【Result & Discussion】

Phase	Primary Function	Assessment Item	SG Mean ± SD	IG Mean ± SD	p	d
	Preparation	1. Posture	4.6 ± 0.5	4.0 ± 0.6	.00*	0.51
	Take back	2. Toss-Up	4.7 ± 0.5	4.0 ± 0.7	.00*	0.56
		3. Take Back	4.1 ± 0.6	3.2 ± 0.9	.00*	0.57
	Loading	Position of Center gravity	4.1 ± 0.7	3.3 ± 0.9	.00*	0.51
		5. Pushing of the legs	4.4 ± 0.6	3.5 ± 0.7	.00*	0.66
		6. Hip rotation	4.2 ± 0.8	3.4 ± 0.9	.00*	0.52
		7. Trunk rotation	4.3 ± 0.6	3.5 ± 0.7	.00*	0.57
		8. Back bending of trunk	4.2 ± 0.6	3.5 ± 0.6	.00*	0.56
		9. Coordination	4.5 ± 0.5	3.7 ± 0.8	.00*	0.60
	Cocking	10. Leg drive	4.3 ± 0.6	3.4 ± 0.6	.00*	0.64
		11. Cocking	4.4 ± 0.6	3.7 ± 0.7	.00*	0.57
		Preparation Phase	47.8 ± 4.5	39.3 ± 5.6	.00*	0.76
	Foward Swing	12. Twist back	4.4 ± 0.4	3.7 ± 0.6	.00*	0.55
		13. Swing	4.5 ± 0.5	3.6 ± 0.7	.00*	0.68
		14. Kinetic chain	4.5 ± 0.5	3.6 ± 0.6	.00*	0.68
	Impact	15. Ball contact	4.4 ± 0.6	3.6 ± 0.8	.00*	0.55
		16. Impact position	4.4 ± 0.6	3.5 ± 0.7	.00*	0.65
		Acceleration Phase	22.2 ± 2.1	18.0 ± 2.6	.00*	0.76
	Follow-Through	17. Follow-through	4.4 ± 0.7	3.9 ± 0.7	.00*	0.40
	Balance	18. Balance	4.5 ± 0.6	4.2 ± 0.6	0.08	0.27
		Follow-Through Phase	8.9 ± 1.0	8.1 ± 1.1	.00*	0.43
		Total Points	79.0 ± 6.8	65.5 ± 8.6	.00*	0.85

*: $p < 0.05$

Validity was examined based on the difference in assessment scores between the SG and IG groups. As a result, significant differences and small to moderate effect sizes were found between the SG and IMG in all evaluation items except "18. balance", the total score of each phase and the overall score (Table 4). Therefore, it is considered that players with superior service action have higher scores in the preparatory phase and the main phase. In this study, significant differences and moderate effect sizes were found in 16 items in the 'preparation phase' and the 'main phase', suggesting that these phases and evaluation items are capable of identifying whether the service movement is superior.

【Conclusion】

The purpose of this study was to develop evaluation criteria for assessing service behavior. The qualitative structure and evaluation items of service behavior were developed from previous studies, and the relationship between the service behavior score and service speed was analyzed. As a result, the following conclusions were obtained.

1) The preparatory phase consisted of four main movements and 12 evaluation items, the main phase consisted of two main movements and five evaluation items, and the terminal phase consisted of two main movements and two evaluation items.
2) There was a significant correlation between service movement scores and service speed.

【Acknowledgment】

This research was supported in part by a grant from Advanced Research Initiative for Human High Performance (ARIHHP), University of Tsukuba.

ISB·JSB FUKUOKA 2023

Relationship between Bilateral Asymmetry in Lower Limb Joint Biomechanics and Jumping Height during Single-leg Countermovement Jump

No.0952

Shota Yamamoto[1], Munenori Murata[2], Rintaro Miyake[1] and Terumitsu Miyazaki[3]

[1] Graduate School of Physical Education, National Institution of Fitness and Sports in Kanoya, Japan.
[2] Toyo University, Japan, [3] National Institute of Fitness and Sports in Kanoya, Japan.

INTRODUCTION

- ✓ Reducing lower limb bilateral asymmetries, such as bilateral asymmetry of jumping height during single-leg CMJ, is beneficial for improving athletic performance and preventing injuries (Bishop et al., 2018, Roman et al., 2015).
- ✓ Examining the relationship between bilateral asymmetry of jumping height and bilateral asymmetry of lower limb joint biomechanics is valuable for developing training aimed at reducing bilateral asymmetry.

PURPOSE

Clarify the relationships between bilateral asymmetry of jumping height and bilateral asymmetry of lower limb joint biomechanics during single-leg CMJ.

CONCLUSION

Reducing bilateral asymmetry of ankle joint torque in the late phase of single-leg CMJ reduces the bilateral asymmetry of jumping height.

METHODS

Data collection

- Twenty-two healthy male collegiate students (20.3 ± 1.3 yr, 67.0 ± 9.2 kg, 171.0 ± 5.1cm) performed five single-leg CMJs each leg in random order.
- Three-dimensional marker trajectories and ground reaction force were measured.

Bilateral Asymmetry Index(BAI) calculation

- **Jumping height**

$$\frac{(JH_{strong} - JH_{weak})}{(JH_{strong} + JH_{weak})} \times 100$$

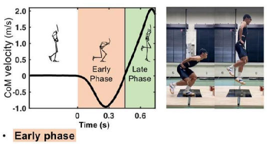
- **Joint Angle and Joint Torque**

$$\frac{(\int Data_{strong}dt - \int Data_{weak}dt)}{(\int Data_{strong}dt + \int Data_{weak}dt)} \times 100$$

(Kobayashi et al., 2013)

JH : Jumping Height
JH_{strong} : Higher JH
JH_{weak} : Lower JH
$Data_{strong}$: Data of lower limb joint with JH_{strong}
$Data_{weak}$: Data of lower limb joint with JH_{weak}

Early and late phase definition



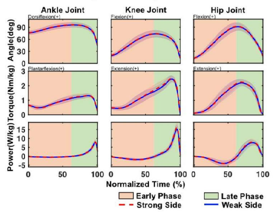
- **Early phase**
  Initiation of motion - CoM reached zero vertical velocity
- **Late phase**
  End of the early phase - Take off

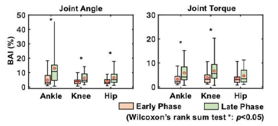
RESULTS & DISCUSSION

Jumping height and BAI of jumping height

	JH_{strong}(m)	JH_{weak}(m)	BAI(%)
mean	0.20	0.18	4.02
SD	0.05	0.03	3.68

Comparison of joint kinematics and kinetics between early and late phases



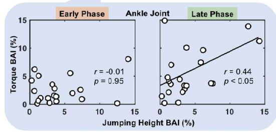


The bilateral asymmetry index of lower limb joint angles and torques in the late phase was greater than that in the early phase. In movements involving consecutive eccentric and concentric contractions in succession, such as CMJ, bilateral asymmetry of muscle force generation might be greater during the concentric contraction than that during the eccentric contraction.

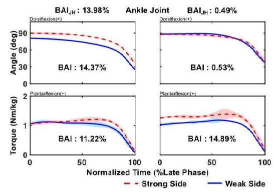
Correlation between BAI of joint angle or torque and BAI of jumping height

	Phase	Ankle Joint r	Ankle Joint p	Knee Joint r	Knee Joint p	Hip Joint r	Hip Joint p
Angle	Early	0.21	0.36	0.10	0.67	-0.29	0.21
	Late	-0.25	0.27	-0.09	0.70	0.28	0.22
Torque	Early	-0.01	0.95	0.09	0.70	0.27	0.23
	Late	0.44	<0.05	0.05	0.82	-0.07	0.76

(Spearman's rank correlation coefficient)



Comparison of participants with large and small BAI of jumping height



Even in participants with a small bilateral asymmetry of jumping height, they exhibit bilateral asymmetry of ankle joint torque.

Relationships between competitive ability and pre-activation time in leg muscles during sprint running and drop jumping in college track and field athletes

Kanta Yokota[1], Ryoya Oga[1], Hiroyuki Tamaki[1]

[1] National Institute of Fitness and Sports in Kanoya

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INTRODUCTION/AIM

Pre-activation (PA) of agonist/antagonist muscles prior to ground contact during running and jumping movements is one of the human motor control mechanisms, and according to previous reports(Horita *et al.*, 1996), positively impacts on motor performance.

We investigated the relationships between the onset time of PA in the lower leg muscles during drop jumps (DJs), sprint running and jumping performance, and competitive ability in Japanese college track and field athletes.

METHODS

Participants: Fourteen male college track and field athletes.

Experimental protocol: DJs from a 60-cm height platform and sprint running for 20 m.

Target muscle: Tibialis anterior, lateral gastrocnemius (LG), medial gastrocnemius, and soleus muscles.

DJ-index: The jumping height (m) / ground contact time (s).

Sprint running performance: The best International Association of Athletics Federations (IAAF) score.

Muscular Activity: The surface electromyographic (sEMG) signals were normalized (expressed as a percentage of the maximum voluntary contraction).

Measurement of PA time: The interval between the onset of muscle activation and ground contact, assessed via sEMG.

DJs

Sprint

RESULTS

DJ-index and PA time

There was no significant correlation for any of the muscles.

IAAF score and PA time

PA time in the TA:
Significantly correlated.
(Figure1)

PA time in the LG:
It was nonlinear, but there was a strong relationship.
(Figure2)

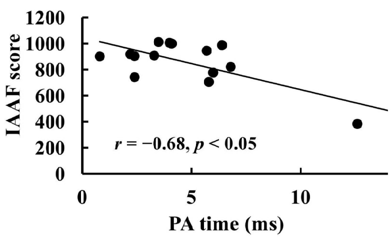

Figure1.
Relationship between
PA time in the TA and IAAF score

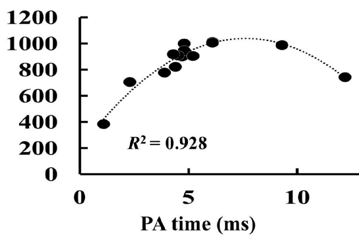

Figure2.
Relationship between
PA time in the LG and IAAF score

CONCLUSION

Our data suggest:

- ➢ The PA time in the LG during the 20 m sprint running and competitive ability can be modeled using a second-order regression.
- ➢ The concept of PA time in the leg muscles predicting the sprint-running performance of athletes may thus be worthy of further discussion.

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Contact: Kanta YOKOTA
Email: m236012@sky.nifs-k.ac.jp