8．女子軽量級一流柔道選手の背負投の筋電図分析
－けんか四つの場合－

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8．An EMG Analysis : Seoi-Nage in Elite Women's Judo Lightweight Class
－ In situations of opposite grip －

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要　旨

福見（2016）は，これまでに相四つの相手における背負投の運動学的研究を行い，その知見を報告した．本研究は，柔道女子エリート選手の背負投の運動学的特徴を明らかにし，トレーニング法あるいは指導法の基礎的資料とすることが目的である．エリート選手を含む３名の女子柔道軽量級選手を対象として，けんか四つの相手に対する背負投の投げ込み動作時の表面筋電を左右７部位から採取した．また被験者が背負投を施技する際に意識する点についてアンケート調査で尋ねた．

結果は以下のとおりであった．

被験者Ａは，上肢の筋力発揮を中心とした施技であるが，終盤に意識的な下肢筋群の筋力発揮を行った施技であった．投げの局面において相四つ時との技術の違いを意識的に行った施技であった．被験者Ｂは，下肢筋群を中心として上肢筋群を加えた筋力発揮による施技であった．相四つ時と同様，高い筋活動が見られるが相四つとけんか四つという組み方の違いによる変化は少なかった．今後上肢筋群への意識的アプローチが技術向上の一助となるかもしれない．被験者Ｃは，上肢と体幹筋群を中心とした施技であった．各筋群への意識的アプローチにより，筋力発揮を高めることが今後の技術向上の一助となるかもしれない．また，被験者３名とも掛け局面で筋活動が盛んであった．崩し，作り局面での筋力向上が今後期待される．

1．Introduction

The majority of research pertaining to the technique Seoi-Nage has been centered around men with few studies conducted on women. This research aims to clarify the kinematics of Seoi-Nage in elite women's light weighted class. In the previous research es about game analysis, Miyake 1) (2015) studied the male categories at the Grand Prix Dusseldorf from 2013- 2015. The study investigated trends in international competitions leading up to the Rio

Olympics games. The results indicated that the following techniques were effective in scoring points: Seoi-Nage, Uchimata, Ippon Seoi-Nage, Yokoshiho-Gatame and Sumi-otoshi. Ishii and the All Japan Judo Federation Research Department 2) (2016) conducted a research at the 2016 Rio Olympic Games. The highest scoring techniques (in terms of the degree of score) were as follows: Seoi-Nage, Uchimata, and Sumi-Otoshi (techniques in order). In terms of women, the highest scoring techniques were Osoto-Gari, Sodetsurikomigoshi and Seoi-Nage. A similar study was conducted at the 2015 Astana World Championships. For men the techniques were Seoi-Nage, Uchimata and Ippon Seoi-Nage. Women techniques were Ouchi-Gari, Ippon Seoi-Nage and Sodetsurikomigoshi. The highest scoring techniques from the perspective of both men and women ranked as follows: Seoi-Nage, Sodetsurikomigoshi, Ippon Seoi-Nage. Ishii concluded that Shoulder throw techniques ranked highly in these competitions despite the recent change in rules.

In a study as for Seoi-Nage, Fukumi 3) (2016) studied Seoi-Nage from aiyotsu situation from three elite lightweight women. The analysis consisted of measuring muscle output throughout the body during Seoi-Nage and conducting an awareness survey and interview on the research subjects. The results were as follows. Subject A had high output from the upper limb muscle group, breaking uke's balance forwards and executing the throw with the extremity of the upper limbs. Subject B recorded high output from the lower limbs, positioning their body between uke's legs and exploding upward. Subject C recorded high output from the rotation of the body and had good timing entering between uke's legs. All subjects recorded the highest output in the kake phase of the throw. Subject A, who had the most results in international competition, recorded a match between muscular output and thought process. On the contrary, Subject B and C recorded a gap between muscular output and thought process.

The prior research was based on Seoi-Nage executed from aiyotsu (tori and uke same handed grip) situation. This research focused on the characteristics of Seoi-Nage executed from kenkayotsu (tori and uke opposite handed grip) situation.

2. Method

2.1 Subjects

The subjects consisted of three lightweight females including one elite athlete (Table 1) who specializes in Seoi-Nage. The Seoi-Nage used in this study was kenkayotsu situation (different grip in both Tori and Uke). The tori performed kuzushi: breaking uke's balance directly forwards, squatted down low, and extended legs upon execution of throw.

The Seoi-Nage was broken down into three phases.

(1) Kuzushi phase: breaking uke's balance
Starting from grip and ending in primary entrance to throw.

(2) Tsukuri phase: positioning set up
From swinging foot rotating into Seoi position.

(3) Kake phase: apply force and throwing of uke

Lifting of uke, and planting of back on tatami.

Table 1. Subject Profile

Subject	*Age*	*Height*	*Weight*	*Dan*	*Y P S*＊	*Kumite*	*Significant results*
A	24	157	50	4	16	Left	London Olympic 5th (2012) World championships 1st (2009)
B	21	151	49	3	15	Left	All Japan Universities Judo Championships 1st (2007) World cup Qingdao 1st (2009)
C	19	154	55	2	12	Right	All Japan Universities team Judo Championships player (2009)
Uke	19	150	48	2	11	Right	
＊Years Practicing Sport							

2.2 Experimental Procedures

The Seoi-Nage was conducted from kenkayotsu situation. Tori preformed Seoi-Nage two times. The complete throw by subjects were used for analysis.

The recording was operated on two synchronized cameras (Canon DV M2 IEEE1394Cable) and shot from the front (anteroposterior) and side (sagittal) views.

Image analysis software DARTFISH Team Pro (Ver. 4,5, Dart Fish Japan Inc.) was used to sync video and electromyogram.

Surface EMG of 14 muscles were measured by a portable multi-purpose bio-signal measurement device (PolymateAP1532, TEAC Inc, 2007). Muscles measured were the palmaris longus, deltoid, trapezius, latissimus dorsi, obliquus externus abdominis, erector spinae, and the rectus femoris of both right and left side.

Monitoring was measured by software AP Monitor at the sampling rate 1kHz. A fast Fourier transform algorithm (FFT) was used to analyze EMG bursts by software BIMUTAS. After analysis, the frequency ranged from 0 to 900Hz.

In addition, a questionnaire survey was taken by the subjects regarding the main points they focused on when executing Seoi-Nage. Interviews were also conducted regarding the answers to the survey.

3．Results and Discussion

3.1 Cased Subject A

(1) Kuzushi phase

From 0.0 seconds, the right external oblique muscle exceeded 200 Hz and simultaneously the output of the left deltoid was 100 Hz. From 0.5 seconds, right and left trapezius were activated with the right side recording an output of 200 Hz. From 0.6 seconds, an output of 350 Hz were recorded on the left deltoid muscle and right lateral dorsi muscle. At 0.9 second, 150 Hz output of the left rectus femoris muscle was recorded.

(2) Tsukuri phase

From 1.2 seconds, an output of 150Hz was recorded from the left rectus femoris and a

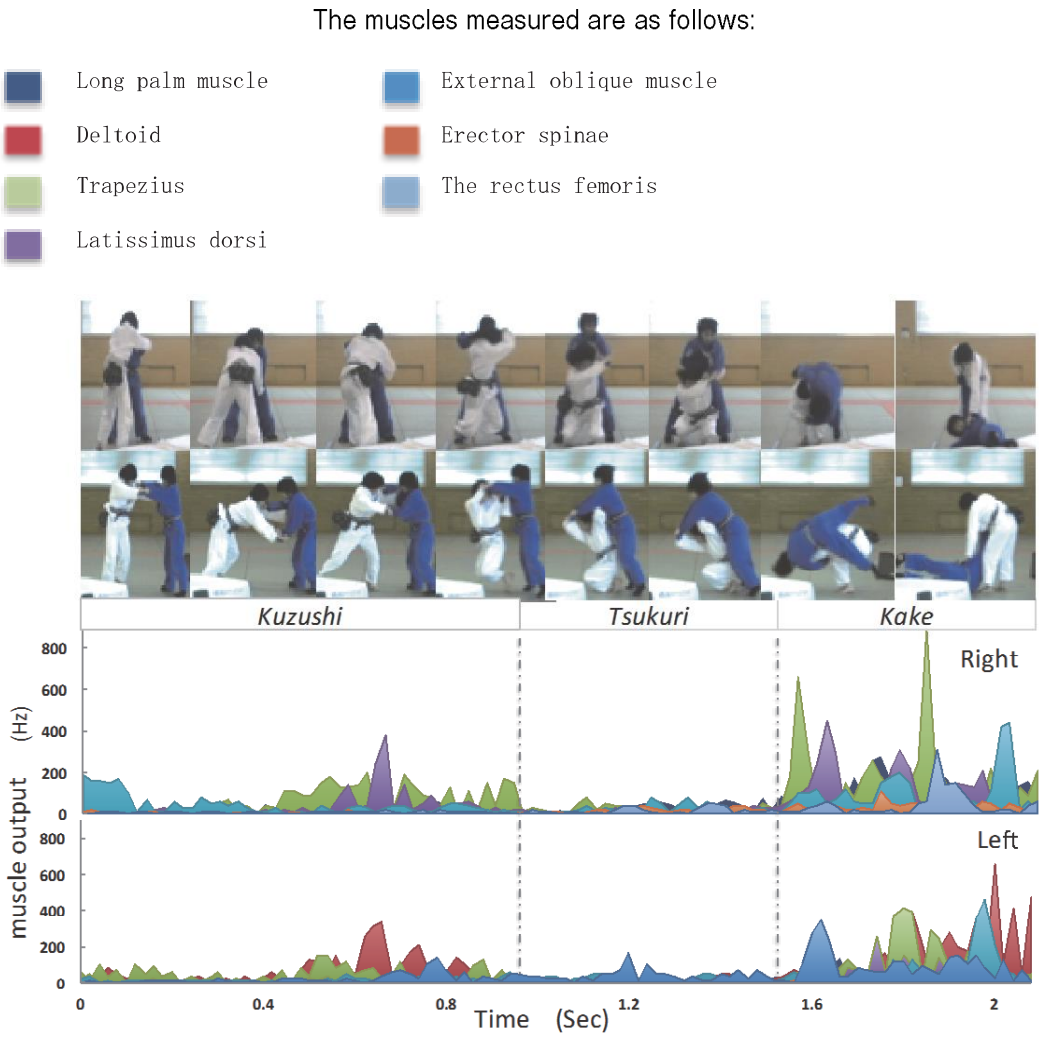

Fig. 1 Subject A's Kenkayotsu Seoi-Nage and muscular output

small output continued from the right external oblique muscle.

(3) Kake Phase

From 1.6 seconds the output of the right trapezius exceeded over 500Hz while the right rectus femoris was 450Hz. At the same time, a 350Hz output was recorded from the left rectus femoris. From 1.8 seconds outputs of the right palmaris longus muscle, left and right trapezius muscles, right and left latissimus dorsi muscles were recorded. The output of the right trapezius muscle exceeded over 500Hz again. From 2.0 seconds the right rectus femoris muscle recorded 300Hz; both left deltoid muscle and right/left external oblique muscle exceeded 450Hz.

(4) Overall

During kenkayotsu, subject A's muscular output recorded from specific muscle groups

occurred at similar times during the kake and kuzushi phases of the throw. In the kuzushi phase the upper limb muscle group was primarily activated. The right rectus femris muscle output was high in the tsukuri phase. The kake phase recorded each muscle groups output on both left and right sides. Fukumi 3) reports reports that Seoi-Nage in the aiyotsu situation that output is withheld in the first half of the throw. In the kenkayotsu situation output was seen in the latter half of the throw. In the aiyotsu situation the upper limb muscle group was activated; however in kenkayotsu the rectusfemoris and left and right oblique muscles recorded high output.

3.2 Cased Subject B

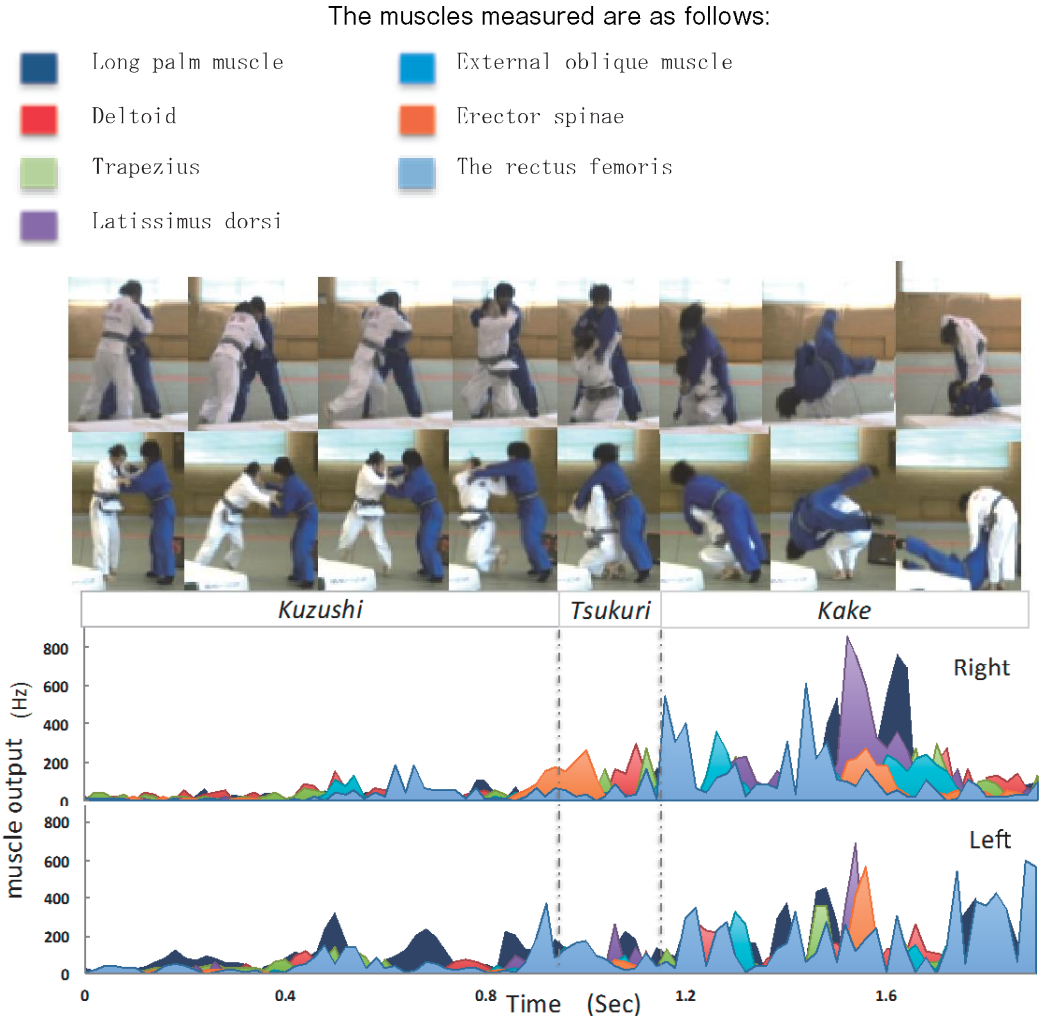

Fig. 2　Subject B's Kenkayotsu Seoi-Nage and muscular output

(1) Kuzushi Phase

From 0.4 seconds the left palmaris longus muscle recorded 300Hz, right rectus femoris muscle 200Hz. From 0.7 seconds the left and right deltoid muscles and left rectus femoris recorded 350Hz.

(2) Tsukuri phase

From 1.0 seconds the erector spinae recorded 250Hz, at the same time both left and right external oblique muscles recorded output. The right palmaris longus muscle recorded 200Hz. The left latissimus dorsi muscle, right deltoid muscle and right trapezius muscle exceeded 150Hz.

(3) Kake Phase

From 1.2 seconds the left rectus femoris exceeded 350Hz; the right exceeding over 500Hz. At the same time the left deltoid muscle recorded 250Hz, the left palmaris longus muscle 300Hz and the left and right external oblique muscles recorded 350Hz. From 1.5 second the right rectus femoris muscle reached 500Hz again while the left trapezius muscle recorded 350Hz. The left trapezius muscle and left and right palmaris longus muscles exceeded 450Hz.

(4) Overall

During subject B's kenkayotsu situation, muscular output peaked in the kake phase of the throw, in particular, the middle phase of the throw. The output of the right and left rectus femoris muscles were significant from the latter half of the kuzushi phase to the end of the kake phase. The peak output of each muscle was high.

Fukumi 3) reports that in aiyotsu Seoi-Nage the right rectus femoris has high output with the throw primarily being executed with the lower limbs. However in the kenkayotsu situation's kake phase, the lower limb muscles as well as the right latissimus dorsi muscle recorded high output. In addition, the peak output was similar to the aiyotsu situation with high output in the kake phase. However the kenkayotsu situation recorded higher output in each muscle group.

From the results above, both aiyotsu and kenkayotsu situations had similar peak outputs in the kake phase. However the overall output was higher in the kenkayotsu situation. In addition, the muscle groups which recorded outputs differed. In the kenkayotsu situation additional effort was exerted in twisting the body and in the pulling motion of the throw.

3.3 Cased Subject C

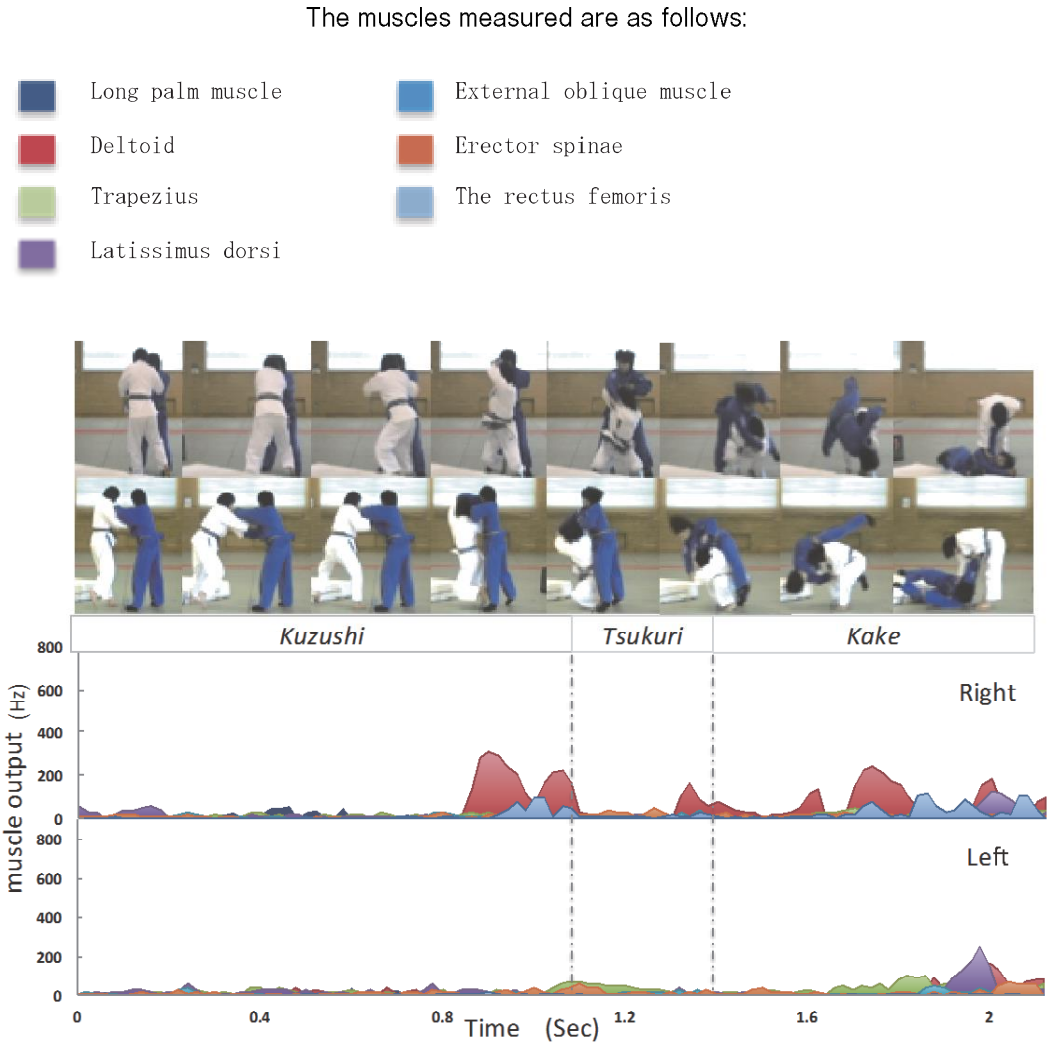

Fig. 3　Subject C' s Kenkayotsu Seoi-Nage and muscular output

(1)　Kuzushi phase

From the early to middle stages each muscle group recorded little output. From 0.9 seconds the right palmaris muscle recorded 300Hz and the right rectus femoris recorded 100Hz.

(2)　Tsukuri Phase

Minimal output was recorded in this phase. From 1.4 seconds the right deltoid muscle recorded 150Hz.

(3)　Kake Phase

Between 1.6 to 2.0 seconds the right deltoid muscle recorded 150Hz and 250Hz. In the finish of the throw the left trapezius, right rectus femoris, the right latissimus dorsi recorded 100Hz, left 250Hz and the left deltoid recorded 150Hz.

(4) Overall

During subject C's kenkayotsu situation recorded output from the right deltoid muscle however overall output was low.

Fukumi 3) reports that in both aiyotsu and kenkayotsu situations for Seoi-Nage, the right deltoid muscle output was significant. In addition each muscle group recorded low output. However in the kake phase of the throw in the aiyotsu situation, the external oblique muscle and rectus femoris output were recorded. On the contrary, the kenkayotsu situation the erector spinae output was observed.

According to the results above, aiyotsu and kenkayotsu situations were similar. There was right deltoid muscles activation and each muscle group's overall output was low. However there was a difference in the kake phase of the throw. In the kake phase of the kenkayotsu situation, more output was generated in the twisting movement of the throw.

3.4 Questionnaire Survey of Seoi-Nage

Table 2. Results of a questionnaire survey about Seoi-Nage

Questions	Subjects		
	A	B	C
Characteristics of seoi-nage	Break opponents balance; using opponents strength instead of own	Pull opponent forward and enter between legs	Enter low with both knees on the floor
Focus points	Once the uke's balance is broken forward, use of upper limbs to throw. Throw is finished as if running forward	Tsurite hands wrist is turned judogi is wrapped between hands	Pulling motion of hikite and rotation of body
Important points in Kenkayotsu	Seoi position is deep Break uke's balance forward Finish the throw	Enter between uke's legs explosively	Rotation of hips. More rotation of hips compared to aiyotsu situation.

3.4.1 Subject A

There was conscious effort in breaking opponents balance forward by supporting the upper limbs in the kake phase. In the kenkayotsu situation, the kake phase had the highest muscular output, especially from the trunk and lower limb muscles. This is due to the conscious effort of following through with the throwing motion until the end of the throw.

3.4.2 Subject B

The uke was first pulled forward with tori entering between uke's legs. Tori then used extension of knees to finish the throw. The kenkayotsu situation recorded higher output in upper and lower limbs compared to aiyotsu situation. This is due to the conscious effort of entering between uke's legs.

3.4.3 Subject C

There was conscious effort to rotate the hips and entering deeper between uke's legs during the kenkayotsu situation compared to aiyotsu. However the muscle activity differed with the right limb muscle group showing high outputs. The overall muscular output was low in kenkayotsu situation due to the use of timing.

4. Conclusions

The measurement of the muscular output and results of the awareness survey during the kenkayotsu situation inidicated that all three subjects recorded the highest muscular output in kake phase of the throw. For powerful throw, more output can be expected in the kuzushi and tsukuri phase of the throw. Each subject recorded unique muscular output during each phase of the throw. Subject A in the kenkayotsu Seoi-Nage situation primarily had upper body muscular output; however the finish of the throw recorded significant output from the lower limbs. A difference in skill level was observed compared to Seoi-Nage in aiyotsu situation. Subject B's kenkayotsu Seoi-Nage starts with output from the lower limb muscle group; output from the upper limbs is added as the throw progresses. High muscular output was recorded and little difference was observed compared to aiyotsu situation. More focus on the upper limb muscles may be the key to improving technique. Subject C's kenkayotsu Seoi-Nage was primarily executed with upper limb muscles and core. A conscious effort to increase the output of each muscle group may be the key to improving the Seoi-Nage technique.

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